The Use of Orthographic Analogy in Children with a Specific Reading Disability

By

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I declare that this thesis is my own work and that, to the best of my knowledge and belief, it does not include i) material from published sources without proper acknowledgment, or ii) material which has been accepted for the award of any other higher degree or graduate diploma in any university.

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Literature Review

Specific Reading Disability and the Use of Orthographic Analogy as a Reading Strategy.

Abstract

Current understanding of specific reading disability (SRD) conceptualises the problem as stemming from a specific deficit in phonological awareness. Phonological awareness is essential to reading development and so a deficit in this skill would impair successful reading acquisition. Research suggests that there is a reciprocal causal relationship between phonological awareness and reading acquisition. It is also suggested that the level of phonological awareness necessary as a prerequisite to reading acquisition lies at the level of onset/rime awareness and that phonemic awareness is a more sophisticated awareness which arises as a product of reading acquisition.

An interactive analogy model of reading development proposes that the initial level of phonological awareness plays an important role in setting up orthographic recognition units which become a basis for reading by orthographic analogy. This reading strategy has been shown to exist from the very beginning of reading and is not a sophisticated strategy as originally suggested by stage-based models. Some theorists argue that an orthographic analogy strategy would reduce the demands on phonological processing and would thus be a beneficial strategy for children with an SRD, however, others have argued that either orthographic or phonological awareness deficits in children with an SRD would limit their capacity to benefit from such a strategy.

Reading disabilities: A broad overview

Reading is a sophisticated and complex skill which involves the successful integration of visual, auditory, cognitive and neurological processes. There exists a substantial number of children who have significant difficulties in learning to read and who appear to be at risk of a continuing downward spiral of learning and perhaps secondary social-emotional difficulties (Stanovich, 1986). An initial success or lack of success in early reading can become magnified as reading is embedded in a particular social, instructional, and cognitive context (Stanovich, 1992). As reading skill develops it becomes more tightly intertwined with other cognitive skills and knowledge bases and, because of this, the cognitive consequences of reading failure can be profound. These factors support the need for a greater understanding of this disability.

Although there is still some debate, many leading researchers view the problem of specific reading disability (SRD) as stemming from a specific deficit in phonological awareness (Aaron, 1989). Evidence suggests that phonological awareness plays a causal role in reading acquisition and therefore a deficit would be a major impediment to successful reading acquisition. In order to better construct remedial programs for children with an SRD it is necessary to investigate the levels of phonological awareness at which a deficit may exist and to relate this to the function of that awareness in normal reading development. Recent studies suggest that the level of phonological awareness necessary as a prerequisite for reading acquisition lies at that of the onset and rime rather than at the phonemic level (e.g., Stahl & Murray, 1994). Awareness of these units is seen as the basis for the use of an orthographic analogy strategy in reading. The aim of this review therefore, is to examine literature concerning the role of phonological awareness in normal reading acquisition and its relationship to the use of orthographic analogy. Current understanding of problems encountered by children with an SRD is examined in light of the literature concerning normal reading development and this is related to the use of orthographic analogy in children with an SRD. The scope of the review covers issues in models of reading acquisition, the role of phonological awareness skills in this process, and the functional units of English orthography, in both normally achieving children and children with an SRD.

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Phonological Awareness and Reading Acquisition

Phonological awareness

A commonly held view in reading research is that the acquisition of basic reading skills depends crucially on metalinguistic skills. One such skill is phonological awareness which involves the ability to recognise the sound units of language and to be able to manipulate them (Stanovich, 1986). Beginning readers must be able to analyse the internal structure of spoken words to discover how the sound segments (*phonemes*) of the language are related to the letters of the written alphabet (*graphemes*). The very nature of English orthography and its' alphabetic characteristics rely on these phonological skills, in comparison to other "pictograph" languages in which it is not necessary to segment words into their constituent phonemes. A working knowledge of phonological units mapped by the orthography requires an appreciation that spoken words are composed of a limited number of phonemic segments which can be combined to generate a virtually infinite number of possible words (Liberman, Shankweiler, Liberman, Fowler, & Fischer, 1977).

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Phonological awareness and reading acquisition: a reciprocal causal relationship

The results of a large number of studies demonstrate a strong and consistent causal relationship between children's ability to recognise and manipulate the constituent sounds of speech and successful reading acquisition (e.g., Bradley & Bryant, 1983, 1985; Jorm & Share, 1983; Juel, 1988; Liberman & Shankweiler, 1985; Tunmer, Herriman, & Nesdale, 1988). Studies also show that training in phonological awareness during, or prior to, reading instruction produces significant advantages in reading achievement (e.g., Ball & Blachman, 1988, Bentin & Leshen, 1993; Fox & Routh, 1984; Lundberg, Frost, & Petersen, 1988). Current research in reading development and SRD suggests that phonological awareness is the best single predictor of reading success and that this relationship holds even when the effects of variables such as intelligence, age, language ability, social class, and memory have been partialled out (Bradley & Bryant, 1985; Goswami & Bryant, 1990; Stanovich, 1988).

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However, further studies of the relationship between phonological processing and reading acquisition have shown an inverse causal connection, that is, that exposure to literacy during reading acquisition enhances phonological awareness (e.g., Morias, Bertelson, Cary, & Algeria, 1986; Perfetti, Beck, Bell, & Hughes, 1987). There is also evidence that some skills in assembling phonology are being acquired along with a visual word recognition process (Stuart & Coltheart, 1988). Together, these results strongly suggest a reciprocal or interactive causal influence between the development of visual or orthographic awareness and phonological awareness during reading acquisition. According to Ben-Dror, Frost, and Bentin (1995), the exposure to clearly defined orthographic segments probably triggers awareness of co-articulated phonemic segments, while at the same time this awareness fosters the acquisition of grapheme-to-phoneme correspondence rules and larger orthographic units. Consequently, although specific details differ many theorists support an interactive view of reading acquisition (e.g., Ehri, 1987; Ehri & Robbins, 1992; Perfetti, 1992; Share, 1995).

Phonological awareness and models of reading acquisition

Traditionally, researchers have responded to the question of how children recognise words by proposing a developmental progression, often in the form of a transition through a sequence of stages. A number of such stage models (e.g., Ehri, 1987; Ehri & Wilce, 1985; Frith, 1985; Gough & Hillinger, 1980; Marsh, Friedman, Welch, & Desberg, 1981), while differing in detail, generally agree that children pass through at least three stages as they learn to read. The initial stage proposed is a "logographic" one, during which children learn associations between pronunciations and whole words. The spelling sequences making up these words remain unanalysed, and are retained more as holistic patterns where salient visual and contextual features are used as the basis of recognition. The second stage according to these models is an "alphabetic" one during which children learn associations between different alphabetic letters (graphemes) or groups of letters and their corresponding sounds (phonemes) and apply this knowledge to their reading. These correspondences are known as grapheme-to-phoneme correspondence (GPC) rules. The final stage proposed by these models is an "orthographic" stage. During this stage children are thought to become able to use larger spelling units in words as a basis for pronouncing new words. Shorter words may be instantly recognised without phonological conversion. Central to the argument of these models is the claim that the level of phonological awareness necessary for learning to read lies at the phoneme unit and that considerable experience with GPC rules is necessary prior to the achievement of the final stage of reading (Ehri, 1992; Ehri & Robbins, 1992; Marsh et al., 1981).

Stage theories of reading development have not fared well in the light of empirical findings (Barron, 1986; Jorm & Share, 1983, Share, 1995; Stuart & Coltheart, 1988). In a review of the literature on word recognition in early reading Barron (1986) notes that evidence does not tend to support either an initially "direct" (lexical, or whole word recognition) or initially "indirect" (nonlexical, or grapheme-phoneme conversion) processing in reading. Evidence suggests that both direct and indirect access may be used in early reading, with the relative contribution of each procedure changing during the course of development (Jorm & Share, 1983). Stuart and Coltheart (1988) argue that phonological awareness can play a role in the very first stage of learning to read amongst phonologically adept children.

<u>Phonological awareness: Prerequisites and products</u>

There has been a tendency to discuss phonological awareness as an homogenous whole. However, it has been suggested that phonological awareness should be viewed as a continuum, ranging from "shallow" to "deep" awareness (Stanovich, 1992), or alternatively, that there are different types of phonological awareness that affect reading in different ways (Goswami & Bryant, 1992). Phonological awareness has been assessed in many different ways, and the tasks involved have been of vastly differing levels of difficulty. It has been demonstrated that children as young as 4 years are aware of rhyme and to some extent alliteration (e.g., Bradley & Bryant, 1983; Maclean, Bryant, & Bradley, 1987), but other tasks are much harder. For example, tasks such as phoneme tapping appear to be possible only for children of ages 6 years and above (Liberman, Shankweiler, Fischer, & Carter, 1974). Phoneme segmentation, phoneme

[because they are learning to read!]

deletion and subtraction tasks (e.g., Yopp, 1988) have proved more difficult again presenting great difficulty until some time after children have begun to read.

Stanovich (1992) argues that tasks which tap the shallow forms of phonological awareness might include the oddity tasks of rhyming stimuli used by Bradley and Bryant (1983, 1985), whereas tasks such as phoneme deletion (Yopp, 1988) would fall on the deep end of the continuum. According to Stanovich, "deep" tasks require more explicit reports of smaller sized units (e.g., phonemes versus onset/rimes or syllables), and are not fostered until later on in reading. Deep phonological awareness appears not to be an absolute prerequisite to reading acquisition, but is itself fostered by an analytic attitude developed during the initial learning of the orthography (Goswami & Mead, 1992). Contrary to stage-based models of reading development, it is argued that the more shallow type of awareness serves as a prerequisite for successful reading acquisition (Bryant, Maclean, Bradley, & Crossland, 1990).

An interactive orthographic analogy model of reading acquisition

Goswami and Bryant (1990, 1992) have proposed that tasks such as those developed by Bradley and Bryant (1983, 1985), which demonstrate an awareness of alliteration and rhyme, may not simply be measuring a "shallow" awareness, but may measure a different type of phonological awareness seen as a prerequisite for learning to read. Goswami and Bryant argue that rhyming is a very different activity as rhyming words are *categories* of words that have a common sound. Once children begin to read they will also encounter orthographic categories that consist of sets of words that contain the same spelling patterns. Often words in orthographic categories will also share the same sound and so will map onto rhyming categories of which a child is already aware. Goswami and Bryant (1992) propose an interactive analogy model of reading development in which early experience with the phonological categories of rhyme and alliteration plays a significant role in helping a child to form orthographic categories on which they will base orthographic analogies. The interactive analogy model conceptualises the further development of reading as an increasingly refined process of lexical analogy. As reading experience progresses, children make finer-grained comparisons between orthographic patterns and phonology, resulting in an increasingly sophisticated awareness of the relationship between orthography and phonology. Initial orthographic awareness may have a fairly gross level of phonological underpinning reflecting the level of phonological awareness prior to instruction, but as reading develops this increasingly reflects phonemic awareness (Goswami, 1993a).

Goswami (1986, 1988, 1993b) claims that children typically use orthographic analogies based on rhyme and alliteration from the very beginning of reading. Using a similar method in most of her studies, beginning readers were shown a clue word (e.g., *beak*), and were then asked to read target words which shared either the first three letters (*bean*), the last three letters (*peak*), or three letters in a different sequence (*lake*), with the clue word. Goswami (1986, 1988) found that, when given a clue word, first- and second-grade children correctly identified more analogy target words than common-letter target words. Thus, Goswami has argued that her research supports the notion that children are capable of using an orthographic analogy strategy from the very beginning of reading acquisition.

The functional units of word recognition

Functional units of a word

Within the analogy framework, the question arises as to what are the functional units of a word that are influential for word recognition and pronunciation. Investigators have proposed that knowledge of spoken language structure plays an important role in the acquisition and successful application of reading skills. The most commonly held view is that the internal structure of the English syllable is hierarchical (e.g., Fudge, 1987). Phonemes in a syllable are said to be organised into groups or units. In this view the syllable has two major subunits, being comprised of the subsyllabic onset and rime that can be phonemes or can be segmented into phonemes (Bowey & Hansen, 1994; Treiman, 1992).

The onset of a syllable or monosyllabic word (e.g., *ver* or *print*) comprises the consonant or consonant cluster preceding the vowel (e.g., /*v*/, /*pr*/). The onset is optional as syllables and words do not necessarily have a beginning consonant (e.g., *in*). The rime consists of the vowel and the consonant or consonant cluster that follows (e.g., /er/, /int/). There is considerable evidence that onsets and rimes function as units of oral language processing and verbal working memory (e.g., Bowey, 1990; Treiman & Chafetz, 1987; Treiman, Goswami, & Bruck, 1990; Treiman, 1994; Treiman & Zukowski, 1988). It has also been found that children find oral tasks assessing their sensitivity to onsets and rimes easier than comparable tasks assessing their sensitivity to phonemes (e.g., Bruck & Treiman, 1992; Treiman, 1985; Treiman & Zukowski, 1991).

Functional units in children's reading

The evidence for orthographic onsets and rimes as functional units of children's reading is less clear cut than the evidence from adults. As previously noted Goswami (1986, 1988, 1993b) has suggested that beginning readers use multiletter units in reading unfamiliar words by analogy to familiar, orthographically similar words. In particular she suggests that the units of onset and rime are most available for transfer in beginning readers. Further evidence also suggests that beginning readers can and do use orthographic rimes in reading unfamiliar words (Treiman, Goswami, & Bruck, 1990). Coltheart and Leahy (1992) further investigated the degree to which children used orthographic rime correspondences or GPC procedures to read nonwords constructed from orthographic rimes that are typically given irregular pronunciations. Whilst they found that subjects did use some rime correspondences, they were more likely to use GPC rules. Their results also showed that the tendency to use orthographic rimes increased from first to third grade and was even greater in adults.

in full ?

details?

Although a rime analogy effect is typically stronger than otherwise similar onset-and-vowel analogy effects, Bowey and Hansen (1994) argue that this effect may not be reliable in children who are only just beginning to read. They suggest also that in second grade children the superiority of rime analogies relative to beginning analogies may reflect the contribution of phonological priming effects (Bowey, Vaughan, & Hansen, 1993). Bowey and Hansen (1994) note that in tasks where phonological priming effects do not operate, the rime advantage is lost. For example, in prose reading, where no phonological priming effects are observed, the rime analogy advantage is not greater than the onset-and-vowel advantage (Goswami, 1988, 1990).

The above sections have examined research concerning the relationship between phonological awareness and reading acquisition and have explored the findings in relation to current models of reading acquisition. An interactive analogy model of reading development and the functional units of transfer in English language syllables for children when using orthographic analogy have been examined. The following section will briefly review current notions of SRD and discuss phonological awareness in SRD in light of an interactive analogy model of reading development.

Specific Reading Disability

Definition

A plethora of terms have previously been used when referring to unexpected reading failure. However, this condition is now most frequently referred as *developmental dyslexia*, or *specific reading disability*. Despite a long tradition of research in the area, defining the condition is still a controversial issue. Whilst most researchers can agree on the basic nature of the problem, due to the difficulties of pin-pointing inclusionary symptoms, definitions have commonly been exclusionary. It has been distinguished from general backwardness in reading or "garden variety" poor readers (Stanovich, 1992) which may result from low intelligence, gross behavioural problems, organic disorders, negative influences such as poor socio-economic background, or poor and disruptive instruction (Rutter & Yule, 1975).

Although nearly all definitions are exclusionary they tend to share one key concept, namely the idea that SRD implies a discrepancy between actual and expected reading performance (Frith, 1985). A great variety of methods have been devised to measure the discrepancy and it has been demonstrated that the use of different methods has an impact on the number of children identified (Rispens & van Yperen, 1990). The methods used basically fall into two categories; ability-achievement discrepancy and age-grade discrepancy methods. Ability-achievement methods generally use IQ to predict an expected reading score which is then compared to the actual reading score. Sophisticated regression models of this type have been proposed by those such as Reynolds (1981). However, studies have found no difference in reading level as a function of IQ in children with an SRD (e.g., Siegel, 1988). This has lead some researchers to conclude that IQ scores should not be included as a definitional characteristic in SRD (e.g., Siegel, 1989; Stanovich & Siegel, 1994).

Currently the most widely used criteria in the research literature appears to be the age-grade discrepancy method. In this method a score is obtained from a standardised reading test and transformed into an age or grade equivalent and then this is compared to the actual age or grade level. A discrepancy is usually considered to be severe if it exceeds two years of reading instruction (Rispens & van Yperen, 1990). Thus, the term *specific reading disability* (or SRD) is used in this thesis to denote children reading substantially below their chronological age where the reading problem cannot be explained by a lack of educational opportunity, gross behavioural problems, or sensory or neurological disorders.

Aetiology of Specific Reading Disability

The major theoretical approaches to the study of causal factors of reading disability include the search for underlying deficits or correlates of reading failure, and for primary aetiological factors. An alternative view to what may be termed the 'pathological' view is the 'normative' approach. It is argued by those who take this approach that previous research has been guided by the view that reading disability is a specific developmental 'disorder', thus implying pathology. Prior (1989) has argued for a normative view of reading disability as an "individual difference distributed like most human characteristics in a normal curve or on a continuum from minimally skilled to exceptionally skilled" (p. 135).

However, the majority of hypothesised explanations of SRD are single factor theories which emphasise a single major underlying cause or deficit, as opposed to the view which postulates multiple deficiencies. Proponents of single factor deficit hypotheses have investigated neurophysiological correlates in an attempt to demonstrate causal relationships. Deficits which have been hypothesised to account for SRD include incomplete hemispheric lateralization (Orton, 1937), a deficit in processing rapid temporal sequences (Tallal, 1984; Farmer & Klien, 1995), verbal short-term memory problems (Torgesen, 1985), disordered language processing (Vellutino, 1979), a deficit in the working memory system (Shankweiler & Cain, 1986), visual processing deficits (Lovegrove, Martin, & Slaghuis, 1986; Livingstone, Rosen, Drislane, & Galaburda, 1991), and phonological deficits (Stanovich, 1992).

Within the past two decades the findings from a large number of studies investigating the language bases of SRD have begun to converge and now suggest a pattern (Stanovich, 1986; Wagner & Torgesen, 1989). This body of research demonstrates that SRD represents a deficit specific to reading (and spelling). That is, these deficits do not reflect limitations to functioning in other cognitive domains. Numerous investigators are now in agreement that individuals with SRD show specific difficulties in the cognitive and metacognitive processing of phonological information (Liberman & Shankweiler, 1985; Stanovich, 1986; Vellutino & Scanlon, 1987).

Considerable discussion has arisen concerning whether a phonological processing deficit found in SRD results from a developmental lag or a specific processing deficit. The developmental lag hypothesis (e.g., Johnston, Prior, & Hay, 1984; Snowling, 1987) suggests that children with an SRD are simply developing more slowly than average readers. In contrast, the specific phonological processing deficit hypothesis, makes the claim that these children have a specific deficit in this area, that is, there is a qualitative difference. Developmental lag hypotheses have not fared well as there is an implicit assumption that these readers will "catch up" to average readers and this does not appear to be the case (Stanovich, 1986).

A Phonological Deficit in specific reading reading disability

As previously noted, there is a general consensus that phonological skills are necessary, if not sufficient, for successful reading acquisition. Research has shown these skills to be important determinants of reading success and failure to master them must be a major impediment to reading acquisition. Thus, it appears that difficulties in phonological skills can play a causal role in the emergence of reading disability. There is a wealth of evidence that deficits in phonological awareness not only appear in conjunction with deficits in basic reading skills (Pratt & Brady, 1988; Vellutino & Scanlon, 1987), but that the relationship is a causal one with deficits in phonological awareness impeding the acquisition of reading skills (Gough & Tunmer, 1986; Lundberg, Oloffson, & Wall, 1980; Stanovich, 1992).

It has been proposed by those such as Aaron (1989), Gough and Tunmer (1986), Rack, Snowling, and Olson (1992), Stanovich (1988), and Siegel (1993) that a deficit in phonological processing may be the core deficit of SRD. Aaron (1989; see also Stanovich, 1992) argues that poor phonological processing skills and no other aspect of language skills are responsible for the reading difficulties of the individual with an SRD. It is suggested that other well documented differences between SRD and normal readers (e.g., in verbal memory, syntax, or semantics) may be the result of early difficulties with phonological skills (Jorm, 1983; Share & Silva, 1987). Stanovich (1986) has argued that poor readers may suffer from what he has termed the "Matthew effect": An initial processing difficulty causes them to fall farther and farther behind as the demands on their skills increase, whereas skilled readers get better and better as they practice the skills they have learned.

Research in the last decade or so has provided ample evidence that individuals with an SRD have problems with phonological awareness (e.g., Liberman & Shankweiler, 1985; Stanovich, 1988; Vellutino & Scanlon, 1987). The phonological awareness of individuals with an SRD has been investigated with a wide variety of tasks and results consistently reveal poor group performance relative to that of normal readers (Torgesen, 1985). For example, phoneme segmentation, blending, and awareness tasks have been shown to differentiate good readers and individuals with an SRD (Bradley & Bryant, 1983; Mann, 1984; Share, Jorm, Maclean, & Matthews, 1984; Snowling, Goulandris, Bowlby, & Howell, 1986; Stanovich, 1988; Wagner & Torgesen, 1987). Success in these tasks has also been shown to be a good predictor of future reading success (Goswami, 1990). It has also been found that individuals with an SRD are slower than normal readers in rapid naming tasks (e.g., Katz & Shankweiler, 1985; Lovett, 1987), and that they cannot generate as many rhyming words as can normal readers and they are slower at doing so (Snowling, Stackhouse, & Rack, 1986). Of significant relevance to the present review is the finding that children with an SRD have poor rhyming skills as assessed by oddity tasks (Bradley & Bryant, 1978). As discussed above, an awareness of rhyme and alliteration precedes the development of reading and is thought to be a prerequisite, whereas other forms of phonological awareness such as phonemic awareness are thought to emerge as a consequence of reading (Goswami & Bryant, 1992).

Based on an interactive account of reading acquisition some theorists have suggested that the deficit in phonological awareness alone may not be sufficient to explain SRD. If reading acquisition relies on the interactive role of orthographic and phonological awareness then the development of SRDs would also be influenced by this relationship. Foorman and Liberman (1989) attribute SRD to inadequate 'bootstrapping' of phonological awareness on orthographic awareness. They suggest that phonological awareness causes success in beginning reading only to the extent that the phonology becomes represented orthographically. In this instance it may be the case that an initial deficit in the awareness of rhyme and alliteration has meant a failure in the formation of an adequate link between these segments and orthographic units. Thus, without this initial 'bootstrapping' there is a consequent failure to develop further 'deep' levels of phonological awareness. Stanovich (1992) also notes the importance of orthographic awareness, independent of phonological abilities, in reading and suggests that some disabled readers may have specific problems in forming orthographic representations, accessing these representations or both. Berninger (1990), in noting the complex relationship between orthographic and phonological awareness, suggests that SRD may stem from a failure of either of these abilities to develop, from a failure of these to become connected, or from a failure of these to operate in concert.

Nonword reading and specific reading disability

Much of the evidence for a specific phonological deficit in SRD comes from nonword reading tasks. A pronounceable nonword (variously termed a 'pseudoword' or a 'nonsense word' by researchers) is an orthographically acceptable but meaningless string of letters. There is ample evidence that readers with an SRD have great difficulty reading nonwords (e.g., Ehri & Wilce, 1983; Snowling, 1981). However, the evidence is inconsistent as to whether individuals with an SRD read nonwords in a manner similar to reading level matched average readers or perform significantly below this group. In studies using reading-level-match designs, children with an SRD are matched with younger normal readers on a measure of word recognition and then compared on a measure of nonword reading. A large number of studies have found the SRD group to be worse in comparison to the reading-level match group on nonword reading tasks (e.g., Manis, Szeszulski, Holt, & Graves, 1988; Snowling, 1980, 1981; Siegel & Ryan, 1988; see also Rack, Snowling, & Olson, 1992 for a review). These studies support the view that most children with an SRD have a phonological deficit. The possibility that their poor phonological reading skills are simply due to their low level of reading ability can be excluded because of the use of the reading-level match group.

Whereas approximately two thirds of the studies reviewed by Rack et al. (1992) found individuals with an SRD to perform below a reading-level matched group, a number of studies (e.g., Treiman & Hirsch-Pasek, 1985; Vellutino & Scanlon, 1987) failed to find a nonword reading deficit in children with an SRD beyond their reading-level. Rack et al. (1992) concluded that the evidence supported the phonological deficit hypothesis for most children with an SRD and suggested that the differences between studies could be accounted for by a number of factors. They questioned the use of comprehension-level reading tests to match groups and lack of verbal IQ matching and also argued that the average younger comparison group in these studies may not have reached a stage in their reading development which allowed them to decode unfamiliar letter strings, thus producing the no difference finding.

In addition, Rack et al. (1992) suggested that the studies that they reviewed which did not show a nonword reading deficit can be partially explained by the use of nonwords which are visually similar to real words. They argue that if nonwords are visually similar to real words (e.g., developed by making a small change to a real word) then participants can read the nonwords by analogy to real words. They state that this involves the use of addressed phonology for visually similar words, and therefore it reduces (but does not eliminate) the demands on phonological processing. Other research supports this proposal. For example Laxon, Coltheart, and Keating (1988) found that nonwords with a large number of neighbours (i.e., nonwords differing from a real word by the change of only one letter in the same position) were more easily pronounced by average readers than nonwords with relatively few neighbours. These results suggest that children are affected by the similarity between nonwords and real words and have been supported by further research (e.g., Treiman, Goswami, & Bruck, 1990). It is suggested that a benefit for phonologically unskilled readers might come about through a reduction in the load on phonological processes by using an analogy strategy.

A study by Treiman and Hirsh-Pasek (1985), reviewed by Rack et al. (1992), in which participants were presented with nonwords after the regular and exception words on which they were based, found the nonwords to be read with atypical ease, the SRD and comparison groups reading the same percent correct. Rack et al. (1992) argue that the participants were 'primed' by the real words and that this lexical facilitation allowed the SRD group to do better than they otherwise would have done. They argue that the findings in this study, and others by those such as DiBenedetto, Richardson, and Kochnower (1983), show a clear benefit for the SRDs and therefore suggests that visual similarity of a nonword to a real word increases the likelihood of a child with an SRD reading it correctly especially if primed.

Orthographic analogy and specific reading disability

As noted previously, research suggests that children with an SRD have deficits in phonological skills and may therefore lack the skills required for an interaction between phonological and orthographic knowledge to occur. Goswami (1993a) argues that the ability to use orthographic analogy is intimately connected to the level of a child's phonological skills. As such, she suggests that these children may be unlikely to be able to use orthographic analogies as a strategy for reading, especially as they have been found to have poor rhyme awareness (Bradley & Bryant, 1978). Even if individuals with an SRD have the cognitive abilities to be able to use analogies they may lack the phonological knowledge necessary to use similarities in orthographic patterns as a basis for making predictions about shared sound.

Alternatively, as noted above, it has been argued (e.g., Olson, Kliegel, Davidson, & Folz, 1985; Rack et al., 1992) that children with an SRD may be able to benefit from the presence of orthographic neighbours (words which are visually similar) and make use of orthographic units larger than graphemes. However, Siegel (1993) suggests that whereas children with an SRD may attempt to use an orthographic analogy strategy they will fail to do so successfully as their phonological deficit would not enable them to conduct the limited segmenting necessary for this strategy. As Goswami (1993a) suggests, the consequence of an absence of phonological awareness is that SRDs may develop recognition units for words that either lack any phonological underpinning, or that have an incomplete or inadequate phonological underpinning. Children with an SRD may be able to recognise individual words in reading, but they will not necessarily be able to use their awareness of the pronunciation of these words as a basis for transfer in analogy. This inability to use analogy would stem directly from a deficit in onset-rime knowledge.

Children with an SRD are thought to learn to read words by holistic recognition (Snowling, 1981), relying heavily on their visual memories to pronounce known words. If this is correct, it would mean that they establish direct recognition units for words that lack phonological underpinning. Children with an SRD have poor phonological skills, and so the interactive process of applying phonological awareness to understand the orthography will be severely hampered. In particular, an initial ability to code orthographic patterns in terms of phonological units like onsets and rimes, and thus use orthographic analogies to build up awareness of the orthography may go some way toward explaining the difficulties experienced by children with an SRD.

Contrary to the proposals by Rack et al. (1992) and Olson et al. (1985) it has been shown that children with an SRD do not appear to connect shared spelling patterns in words spontaneously in the way required for analogy. Manis, Szeszulski, Howell, and Horn (1986) compared the use of analogy- and rule-based strategies in normal and SRD children with a set of nonwords constructed from real words so that the use of one strategy for pronunciation would produce a different response to the other. They found that the children with an SRD lagged behind age-matched controls in the use of both strategies, and behind reading-age matched controls in the use of analogies but not rules. A more recent study by Lovett, Warren-Chaplin, Ransby, and Borden (1990) investigated the use of orthographic analogies in children with an SRD by giving them lists of analogous (rhyme) words to read, as part of their study which compared the effectiveness of two experimental word recognition training programs (one that instructed constituent letter-sound mappings and one that instructed both regular and exception words by a whole-word approach). They found no spontaneous transfer to new words and it was concluded that the children were not able to make use of analogies. They suggest that these children may have a tendency toward item-specific learning.

In assessing the salience of particular subsyllabic units in children with an SRD, Fayne and Bryant (1981) found that reading disabled children read more generalisation words (*cop* or *pot*) correctly after post-vowel training (blending *co-t*) than after onset-rime training. In normal beginning readers, on the other hand, onset-rime segmentations have been found to be more useful (Goswami, 1986, 1992; Wise, Olson, & Treiman, 1992). However, Bruck and Treiman (1992) found that while learning to pronounce words on the basis of rimes works well at first, vowel training achieves the best long-term results in generalising to nonwords, compared to rime or consonant-vowel training.

Van Daal, Reitsma, and van der Leij (1994) addressed the issue of whether disabled readers can be instructed to use certain within-word units in Dutch. Several analogy methods were employed by van Daal et al. (1994) in which children repeatedly practised test words segmenting at various junctures (e.g., post-vowel, onset/rime). They found that all types of practice were beneficial for the practised words but that segmentations according to the onset-rime principle had no more effect on the speed of naming words than segmenting written and spoken words at other boundaries. Unfortunately this study did not include chronological- or reading-age matched control groups and thus comparisons cannot be made to the use of specific units for transfer in normal reading acquisition process. They note, however, that a division in onsets and rimes could play a role in the accuracy of reading in English in which the vowel sound is much more dependent upon the following consonants than in Dutch (Goswami, 1993b).

Conclusions

Children with an SRD have a deficit in phonological processing which appears to be causally related to their failure to master successful reading acquisition. Research concerning this deficit has often failed to specify or investigate the level of awareness at which this deficit occurs. Thus, attempts to relate a deficit to a delay in development or stalled development at a certain stage of reading acquisition may be misguided. Stage-based theories of reading development posit the phoneme as the level of awareness necessary for initial reading in which a GPC strategy is seen as the method for reading. The ability to use orthographic analogy and direct access is said to develop after much experience with a GPC strategy. However, current research supports the conclusion that phonological awareness at the level of onset and rime is a prerequisite for learning to read and that phonemic awareness develops largely as a consequence of learning to read. Children then use these units to access orthography and are then able to use an orthographic analogy strategy based on these units on which to develop an awareness which increasingly reflects the phoneme. It may be the case that children with an SRD have failed to develop adequate awareness at the level of onset and rime units and thus suffer from inadequate 'bootstrapping' of orthographic awareness onto phonological awareness. Further investigation concerning the levels of phonological awareness at which a deficit may lie in children with an SRD and their ability to use strategies such as orthographic analogy which may be integral to further reading development, needs to be conducted. With such knowledge it may then be possible to construct remedial programs specifically targeted to address the problem.

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Empirical Study

The Use of Orthogrphic Analogy by Children with a Specific Reading Disability

Abstract

A nonword orthographic analogy task, similar in method to that devised by Goswami (1993) was used to investigate the ability of children with a specific reading disability (SRD) (mean age = 9.6 years), reading-age (RAM) (mean age = 6.8 years), and chronological-age (CAM) (mean age = 9.5 years) controls (n = 15 in each group), to benefit from the availability of a real "clue word" upon which an orthographic analogy can be based. The present study manipulated the subsyllabic units of onset, onset-and-vowel, rime and final consonant/s, available for transfer from a clue word to a nonword. The complexity of nonword structure was also manipulated, increasing complexity from consonant-vowel-consonant trigrams to nonwords including consonant clusters at either initial of final positions. Participants were assessed at pre-test on their ability to read a set of nonwords and again at post-test during which a clue word was made available.

In line with predictions RAM and CAM controls showed an increase in performance from pre-test to post-test whereas the SRD group showed no significant increase. In agreement with previous research the SRD group also showed a nonword reading deficit compared to the RAM group. Contrary to predictions, the groups did not differ in the effect of nonword structure complexity. RAM and CAM groups also showed no significant difference in the effect of subsyllabic orthographic unit of transfer, however the SRD group performed better when the unit for transfer was that of the onset. An analysis of error patterns found no significant difference between the RAM and SRD groups on number of real word errors, however, different error patterns suggest an over-reliance by the SRD group on the initial consonant/s of a nonword. It is suggested that children with an SRD fail to note the internal structure of a word and rely on partial decoding of the initial segment and guess at the rest of the word.

A large body of research developed over the past 20 years supports the claim that specific reading disability (SRD) is linked to a deficit in phonological awareness, which is generally defined as the ability to recognise and manipulate the constituent sounds of speech (for reviews see Liberman & Shankweiler, 1985; Rack, Olson, & Snowling, 1992; Stanovich, 1986; Wagner & Torgesen, 1987). Evidence supports a strong and consistent causal relationship between children's phonological awareness and successful reading acquisition even when the effects of variables such as intelligence, age, language ability, social class, and memory have been partialled out (e.g., Bradley & Bryant, 1983, 1985; Liberman & Shankweiler, 1985; Rohl & Pratt, 1995; Tunmer, Herriman, & Nesdale, 1988). Studies also show that training in phonological awareness during, or prior to, reading instruction produces significant advantages in reading achievement (e.g., Ball & Blachman, 1988, Bentin & Leshen, 1993; Lundberg, Frost, & Petersen, 1988).

There is considerable evidence that the relationship between phonological processing and reading acquisition is an interactive one. Research has shown that exposure to literacy during reading acquisition enhances phonological awareness (e.g., Morias, Bertelson, Cary, & Algeria, 1986; Perfetti, Beck, Bell, & Hughes, 1987). Evidence also suggests that phonological awareness is being acquired along with a visual-orthographic awareness (Manis, Custudio, & Szeszulski, 1993; Stuart & Coltheart, 1988). Together these results strongly suggest a reciprocal or interactive causal influence between the development of orthographic awareness, an "attention to orthographic (letter-based) *detail*" (Share, 1995, p. 171), and phonological awareness during reading acquisition. According to Ben-Dror, Frost, and Bentin (1995), the exposure to clearly defined orthographic segments probably triggers awareness of phonemic segments, while at the same time this awareness fosters the acquisition of grapheme-to-phoneme correspondence rules. This interactive view of reading acquisition has received growing support (e.g., Ehri, 1987, 1992; Ehri & Robbins, 1992; Goswami & Bryant, 1992; Perfetti, 1992; Share, 1995).

Researchers who adhere to stage-based models of reading development (e.g., Ehri, 1992; Ehri & Robbins, 1992; Frith, 1985; Marsh, Desberg, & Cooper, 1977; Marsh, Friedman, Welch, & Desberg, 1981) argue that the phonological awareness required for initial reading acquisition lies at the phonemic level. These theorists claim that following initial logographic stages, children learn to read by a strategy that consists of the use of grapheme-to-phoneme correspondence (GPC) rules in which phonemes are assigned to individual graphemes in the decoding of words. However, recent literature on phonological development suggests that a phonological awareness based on alliteration and rhyme emerges prior to phonemic awareness, the latter being largely a product of reading experience (Bradley & Bryant, 1983; 1985; Bryant, Maclean, Bradley, & Crossland, 1990; Goswami & Mead, 1992; Lenel & Cantor, 1981; Treiman & Zukowski, 1988). There is also much evidence to support the claim that rhyming ability in the preschool years is an important predictor of later reading success (e.g., Bradley & Bryant, 1983; Lundberg, Olofsson, & Wall, 1980).

Goswami and Bryant (1990, 1992) have proposed a model for reading development which includes a link between rhyming and reading acquisition. They suggest that an initial awareness of alliteration and rime forms the basis for noticing common orthographic units between words. They note that the phonological units of alliteration and rhyme are congruent with the orthographic segments of onset and rime. The onset of a syllable or monosyllabic word (e.g., *ver* or *print*) comprises the consonant or consonant cluster preceding the vowel (e.g., /v/, /pr/). The onset is optional as syllables and words do not necessarily have a beginning consonant (e.g., *in*). The rime consists of the vowel and the consonant or consonant cluster that follows (e.g., /er/, /int/) (Fudge, 1987; Treiman, 1992). As the basis for an interactive analogy model of reading acquisition, Goswami (1993a) proposes that experience with rhyme and alliteration categories will play a significant role in helping a child to form orthographic categories. These categories are seen as the basis on which orthographic analogy as a strategy for reading is formed.

Goswami's work (1986, 1988, 1993b) supports her claim that beginning readers use multi-letter units in reading unfamiliar words by analogy to familiar, orthographically similar words. Using a similar method in her many studies, beginning readers were shown a clue word (e.g., *beak*), and were then asked to read target words which shared common letters with the clue word, for example, either the first three letters (*bean*), the last three letters (*peak*), or three letters in a different sequence (*lake*). Goswami found that, when given a clue word, first- and second-grade children correctly identified more onset and rime analogy target words than words containing other segments, with the effect stronger for orthographic rime analogy words. A recent study by Walton (1995) found, in support of Goswami's model, that for high prereading skilled children, beginning to read was easier if an orthographic analogy based on rhyming could be used to read a new word than when decoding based on GPC rules was required.

With regard to the subunits on which analogy may be based research suggests that orthographic onsets and rimes definitely function as units for reading in adults (e.g., Bowey, 1990, 1993; Treiman, 1994; Treiman & Chafetz, 1987; Treiman, Goswami, & Bruck, 1990; Treiman & Zukowski, 1988). However, the evidence for the use of these units by children is less consistent. A study by Stahl and Murray (1994) suggests an ability to manipulate onsets and rimes relates more strongly to reading achievement than does phonemic awareness. Other evidence suggests that beginning readers can and do use orthographic rimes in reading unfamiliar words (e.g., Treiman, Goswami, & Bruck, 1990). However, Bowey and Hansen (1994) found that although available from the very beginning of learning to read, proficiency in the use of orthographic rime analogy increases with word-level reading proficiency.

As previously stated, Goswami's (1993b) interactive analogy model of reading development is based on the notion that early experience with the phonological categories of rhyme and alliteration allows for the formation of orthographic categories such as onsets and rimes on which they will base orthographic analogies. Similarly, Foorman and Liberman (1989) suggest that phonological awareness causes success in beginning reading only to the extent that the phonology becomes represented orthographically. Based on an interactive account of reading acquisition Foorman and Liberman attribute SRD to inadequate 'bootstrapping' of phonological awareness on orthographic awareness. Stanovich (1992) also notes the importance of orthographic awareness, independent of phonological abilities, in reading and suggests that some disabled readers may have specific problems in forming orthographic representations, in accessing these representations, or both.

A key piece of evidence for Stanovich's (1992) claim comes from Reitsma (1983). He found that wheras although first-grade readers were able to recognise a set of practised words amongst matched words with homophonic spellings, a learning-disabled group two years older but approximately matched with the first-graders on reading level did not perform better on the standard spelling even after substantial practice. Stanovich (1992) argues that this suggests some disabled readers have specific problems in forming or accessing orthographic representations, specifically for larger orthographic units such as those based on correspondences with onset and rime. However, the bulk of research investigating orthographic awareness in SRD samples has shown that their orthographic skills match or even exceed that of reading-age controls (e.g., Bruck, 1990; Olson, Kliegel, Davidson, & Foltz, 1985). Despite the earlier proposal by Stanovich (1992) recent research by Stanovich himself has supported this finding (Stanovich & Siegel, 1994), with a further study by Siegel, Share, and Geva (1995) reporting similar results.

Thus as an alternative to the proposal that SRD may have a basis in inadequate orthographic awareness, it has been suggested that as children with an SRD have relatively intact orthographic awareness they should benefit from an orthographic analogy strategy. Rack, Snowling, and Olson (1992) suggest that the studies they reviewed that did not show a nonword reading deficit (e.g., DiBenedetto, Richardson, & Kochnower, 1983; Treiman & Hirsh-Pasek, 1985) can be partially explained by the use of nonwords which are visually similar to real words. They argue that if nonwords are visually similar to real words then participants can read the nonwords by analogy to real words. This would involve the use of orthographic representations for visually similar words and, therefore, it would reduce (but not eliminate) the demands on phonological awareness. This is based on the notion that analogy mechanisms require an adequate orthographic awareness and some, although not complete, phonological analysis (Stanovich, 1992). If children with an SRD have a phonological deficit alone, and not a problem in orthographic awareness or the formation of a connection between the two, a benefit may come about through a reduction in the load on phonological awareness. This argument has also been proposed by Olson et al. (1985). ?

However, Siegel (1993) suggests that although children with an SRD may attempt to use an orthographic analogy strategy to read nonwords or unfamiliar real words, they would be unable to do so because of their phonological deficit. In an earlier study (Siegel, 1986), she found that children with poor phonological skills often read nonwords as real words. Siegel argues that this is due to the children arriving at an incorrect phonetic rendering of the nonword by using an analogy strategy but not being able to segment and blend correctly at the appropriate juncture in the word. She states that to read a nonword such as *'skib'* by analogy to *'skin'* the child must be able to segment *'ski'* and then blend with *'b'*. This may not constitute a sufficient reduction in demand on phonological awareness to overcome a phonological deficit.

Goswami (1993) agrees with Siegel's (1993) proposal suggesting that children with an SRD may be unlikely to use orthographic analogies effectively as a strategy for reading. Even if individuals with an SRD have the cognitive abilities to be able to use analogies and adequate orthographic awareness they may lack the phonological awareness necessary to use similarities in orthographic patterns as a basis for making predictions about shared sound. She argues that an initial inability to form connections between orthographic patterns and phonological units like onsets and rimes, and to use orthographic analogies to build up knowledge about the orthography, may go some way towards explaining the difficulties experienced by children with an SRD. Goswami suggests that children with an SRD, instead, learn to read words by holistic recognition (Snowling, 1981), relying heavily on their visual recognition to pronounce words.

Thus, at the theoretical level there are conflicting views as to the ability of children with an SRD to use an orthographic analogy strategy. Unfortunately the available empirical evidence does not clarify the issue. Contrary to the proposal of Rack et al. (1992) and Olson et al. (1985) it has been found that children with an SRD do not appear to connect shared spelling patterns in words spontaneously in the way required for analogy. Manis, Szeszulski, Howell, and Horn (1986) compared the use of analogy- and rule-based strategies in normal and SRD children with a set of nonwords constructed from real words so that the use of one strategy for pronunciation would produce a different response to the other (see Marsh et al., 1977, for a similar method). They found that the children with an SRD lagged behind chronological-age matched controls in the use of both strategies, and behind reading-age matched controls in the use of analogies but not rules. A more recent study by Lovett, Warren-Chaplin, Ransby, and Borden (1990) investigated the use of orthographic analogies in children with an SRD by giving them lists of analogous words to read as part of their study, which compared the effectiveness of two experimental word recognition training programs. They also found no transfer to new words and it was concluded that the children were not able to make use of analogies.

However, other studies provide some evidence for training in the strategy as being effective (e.g., Gaskins et al., 1988). Wolff, Desberg, and Marsh (1985) investigated the use of two alternative analogy strategy training instructions with reading disabled 5th grade children compared to normally achieving children in 2nd and 5th grades. They found that both training instruction sets improved performance in the analogy task in all groups, with the SRD group performing in a similar manner to the 2nd grade group.

Van Daal, Reitsma, and van der Leij (1994) addressed the issue of whether reading disabled children use within-word units in Dutch. Several analogy methods were employed by van Daal et al. (1994) in which children practiced test words segmenting at various junctures (e.g., post-vowel, onset/rime). They found that segmentations according to the onset-rime principle had no more effect on the speed of naming words than segmenting written and spoken words at other boundaries. Unfortunately this study did not include chronological- or reading-age matched control groups and thus comparisons cannot be made to the use of specific units for transfer in normal reading acquisition process. However, they note that a division in onsets and rimes could play a role in the accuracy of reading in English, especially of very beginning readers or prereaders (Goswami, 1986, 1993; Wise, Olson, & Treiman, 1990). An earlier study of within-word units in English by Fayne and Bryant (1981) found that reading disabled children read more generalisation words (*cop* or *pot*) correctly after post-vowel training (blending *co-t*) than after onset-rime training (*c-ot*).

The optimal level of spelling-to-sound unit for children with an SRD is not known, although this question has been addressed by Olson and Wise in research on computerised reading instruction. Early results from their research suggested that participants with an SRD may benefit from segmentation training at the level of onset-rime (Wise et al., 1990). However, later results failed to replicate an advantage for onset-rime segmentation over other segmentation conditions (Olson & Wise, 1992).

The purpose of the present study, therefore, is to examine the performance of children with an SRD on a task designed to assess use of an orthographic analogy strategy in the reading of nonwords and to investigate the salience of different subsyllabic units as functional reading units. A method similar to that used by Goswami (1993a) is adopted, involving provision of a 'clue-word' upon which the analogy can be based. Nonwords, which conform to the rules of English orthography and pronunciation, are used in the study to ensure that participants use either an orthographic analogy strategy and access orthographically similar words, or GPC rules, to read rather than direct access to a lexicon of known words. in full

Previous studies have shown that a phonological deficit in children with an SRD causes profound difficulty in reading nonwords when compared to both a reading-age matched (RAM) group, and a chronological-age matched (CAM) group (see Rack, Snowling, & Olson, 1992 for a review). Therefore, it is hypothesised that children with an SRD will read fewer nonwords correctly overall than a RAM group, and that the RAM group will score lower than a CAM group.

Studies such as that by Manis, Szeszulski, Howell, & Horn (1986) have found that children with an SRD do not spontaneously use orthographic analogy, however these studies did not provide a clue word which was visually present. The stimuli used in their experiments also consisted of nonwords based on real words of some complexity (e.g., *leopard/leopark*, *garage/farage*). Considering that children with an SRD may suffer from a 'Matthew effect' (*the poor get poorer*) (Stanovich, 1986), it is reasonable to suggest that in the above experiments an SRD group may not have had these words available in a lexicon from which to base analogy. It is hypothesised that children with an SRD may benefit from the availability of a clue word on which to base orthographic analogies. However, it is also hypothesised that children with an SRD and younger average readers would benefit less from a clue word from which to make analogies than? compared to average readers of the same chronological age as the children with an SRD. Also, due to the simple structure of the words, and evidence from training studies, it is predicted that SRDs may gain some benefit from the clue word whilst performing below the level of the RAM group due to their phonological difficulties.

needs rewriting?

Present study

The experiment manipulates the complexity of the nonword structure in order to determine the effect of this on the use of an orthographic analogy strategy. Thus, words containing consonant clusters (consonant-vowel-consonant-consonant /CVCC/, and CCVC) are presented as well as more simply structured CVC words. Whereas Snowling (1981) found that consonant clusters only presented difficulties for children with an SRD compared to RAM controls when presented in bi-syllabic words, a consonant cluster in a word, especially in the initial position, has been found to impose a difficulty upon children with an SRD (e.g., Lewkowicz, 1980). Goswami (1993) investigated the effect of consonant clusters on orthographic analogy transfer in beginning and final positions with 7-year old beginning readers and found no significant transfer of beginning consonant clusters. This represents a contradiction to her previous findings which did find significant levels of transfer. She suggests that onset effects may be less robust than rime effects, especially when including consonant clusters.

Thus it is hypothesised that with increasing complexity (CVC being least complex, followed by CVCC then CCVC) nonwords would be more difficult to read. An interaction for nonword structure by group is expected. As the older CAM group have relatively well developed phonological decoding skills it is predicted that they will show little difference in ability to read CVCC and CCVC structures, whereas the RAM group will have more difficulty with the CCVC structure and show less transfer in the analogy task (Goswami, 1993a). It is hypothesised that the SRD group will perform below RAM and CAM groups on all nonword structures and that their performance on the CCVC structure will show even less transfer on the analogy task than the RAM group performance.

Although there is evidence to show that the subsyllabic units of onset and rime play a role in the performance of both beginning and skilled readers on particular verbal tasks, the results of studies that have examined the salience of these units in children with an SRD are inconclusive (e.g., Fayne & Bryant, 1981; Olson & Wise, 1992). To examine the role of these units further, the experiment manipulates the specific word segmentations of onset-rime, and the post-vowel segmentations of onset and vowel-final consonant/s to establish whether certain segmentation units are more salient or beneficial as units for transfer in analogy for children with an SRD. Nonwords have been constructed from the real clue word to include either the onset, onset and vowel, rime, or final consonants. It is hypothesised that there will be an interaction for analogy transfer unit by group. RAM children will show most transfer of the rime unit followed by the onset unit, the CAM group will show a similar pattern of transfer and it is hypothesised that the SRD group may benefit most from the onset, and onset and vowel units.

As a further aim of this research was to ascertain whether the groups differ in the strategies they use to assemble pronunciations for unfamiliar words or nonwords, error patterns will be examined. Differing distributions in error patterns may indicate qualitative differences between the groups in strategies for reading rather than, or in addition to, a quantitative difference in proficiency in strategy use. Research with children with an SRD in which error patterns have been analysed has been contradictory in findings. Some researchers such as Venezky (1976) have found what they consider to be qualitative differences in error patterns between SRD groups and controls, whereas others have argued that the distribution of errors in their results does not provide support for the hypothesis that children with an SRD use decoding processes that are qualitatively different from other groups.

Method

Participants

Participants were 45 children attending public primary schools in Southern Tasmania districts. Participants had no gross behavioural problems or organic disorders, normal educational opportunities, and were from English speaking backgrounds. Permission was obtained from schools and parents prior to assessment of participants. Reading age (RA) was assessed using the Neale Analysis of Reading Ability-Revised (Neale, 1988). On the basis of reading and chronological age levels three groups of children were selected: 1) 15 children (4 female, 11 male) with an SRD as defined by a reading age of 24 months or more below their chronological age (CA), with a chronological age range from 8 years 4 months to 10 years 7 months; 2) 15 children (7 female, 8 male) selected from the same chronological age range as the SRD group (CAM group), with a reading age not falling below their CA and no greater than 12 months above their CA. Ages ranged from 8 years 8 months to 11 years; 3) 15 children (3 female, 12 male) with reading ages in the same range as the SRD group (RAM group), with a reading age not falling greater than one month below their CA and being no greater than 12 months above their CA.

All participants were assessed with subscales from the Wechsler Intelligence Scale for Children-III (WISC-III; Wechsler, 1992) and children were included in the study provided they had a Full-scale IQ estimate of 85 deviation quotient points or above. Groups were matched on this variable. Full-scale IQ estimates were obtained from a short form of the WISC-III (Vocabulary, Similarities, Block Design and Picture Completion). Deviation Quotients, which have a mean of 100 and a standard deviation of 15, were calculated using the procedure given in Sattler (1988). Sattler (1988) suggests that simple prorating and regression procedures are not applicable in estimating an IQ score from short forms as they do not deal adequately with the problem of subtest reliability.

Means and standard deviations for each of the groups on the variables of chronological age, reading age and Full-scale IQ estimate are shown in Table 1. Data for individual participants on these variables are given in Appendix A. One-way ANOVAs indicate no significant differences between the SRD and CAM groups on chronological age, the SRD and RAM groups on reading age, or the groups on estimated full-scale IQ (See Appendix B).

Table 1. Means for chronological age, reading age, and IQ estimate, for each experimental group.

	Group[a]		
Variable	Specific Reading Disability	Reading-age Matched	Chronological-age Matched
Chronological Age (in months)	115.46 (8.28)	82.47 (7.73)	114.43 (8.51)
Neale-R Accuracy Reading-age (in months)	84.47 (8.47)	84.80 (8.61)	118.20 (9.47)
Estimated WISC-III Full-scale IQ	105.80 (11.37)	109.73 (12.34)	106.73 (11.40)

[a]n = 15 for each group.

Note. Standard deviations are given in parentheses (SD).

Only Av?

Stimuli

The stimuli used consisted of 15 sets of 12 nonwords with a real 'clue-word' for each set. Nonwords were constructed to include specific units from the real clue-word. Nonwords were selected as stimuli to ensure that subjects had no prior knowledge of these words. The nonwords conformed to the rules of English pronunciation and orthography.

Due to the difficulties in constructing three and four letter nonwords which complied to all the experimental variables some words were used which may be found in the *Collins English Dictionary - Australian Version* (1992). In all cases however, these words are not in common usage in Australian English, being classified as either *archaic*, *informal Brit.*, *informal Scot.*, *acronym*, or *foreign language*. All nonwords contained closed syllables only, and where possible rimes were selected that were both regular and consistent (as defined by Stanback, 1991). In cases where it was not possible to select consistent rimes, all possible pronunciations of the letter string were noted as correct. For example, the variant rime of the nonword 'drut' may be pronounced as in 'but' or as in 'put', so both pronunciations were considered correct. Initial consonant clusters were selected from the Syllable Construction Chart (Lindamood & Lindamood, 1975). No digraphs were used.

Three types of word structure were used; consonant-vowel-consonant (CVC), CVCC with a final consonant cluster, and CCVC with an initial consonant cluster. Five real clue-words were selected of each type of word structure. From each of these clue-words 12 nonwords were constructed. These included three examples of each of four different word unit words. For example, from each clue word (e.g., pat) 12 nonwords were constructed, 3 containing the onset only (e.g., pob), 3 containing the onset plus the vowel (e.g., pag), 3 containing the rime, (e.g., jat) and 3 containing the final consonant or consonant cluster only (e.g., fut) (*underlining has been used here for explanation purposes only*). A full list of all stimulus words and nonwords is given in Appendix C. No control condition was included in the word unit type variable as the measure of interest was the difference in performance between each word unit type and relative amount of improvement across groups. Each clue-word and nonword was presented in isolation on a white background card (15x10 cm) in black 24pt, lower case Avant Garde type.

Procedure

The children were seen on three separate occasions following receipt of permission forms. These consisted of an initial session for administration of the Neale Analysis of Reading Ability-Revised (Neale, 1988) on which basis participants were selected and allocated to one of the three groups: children with an SRD, chronological age group, and reading age group. A second session was held for the administration of the WISC-III subtests, and a third for the experimental session during which the pre-test and post-test orthographic analogies tasks were given. Each child was assessed separately in a quiet room.

To assess the use of orthographic analogy, a method similar to that devised by Goswami (1993) was employed. The orthographic analogy task involved pre-test and post-test conditions. In the pre-test condition the child was asked to read a set of 12 nonwords. Standard instructions were used for each child; ? Cards ?

> "I'm going to give you some words which have words on them that I want you to say out aloud for me. These are not real words, they are nonsense words but you can still say them just like with real words. If you are not sure how to say some of the words have a guess at how you think they might be said. You don't have to read them quickly, you have as much time as you need. Start with this one."

Pronunciations were recorded by the experimenter. Following this, in the post-test condition for the same set of words, the children were shown a real clue-word which were asked to? they pronounced aloud. If a child was unable to do so the pronunciation was given by the experimenter. The word was not sounded out phoneme-by-phoneme, nor were any other strategies for pronunciation suggested by the experimenter. The clue-word was left on the table and it was suggested that the child may wish to use the word to help them pronounce the nonwords. The child was then asked to read the set of 12 nonwords aloud. This procedure was repeated for each of the 15 sets. Presentation of the nonwords was counter-balanced by type of word structure, clue-word set, and within each clue-word set.

Design

The experiment was a [3] x 2 x 3 x 4 design: group (SRD / CAM / RAM) x test (pre-test / post-test) x type of word structure (CVC / CVCC / CCVC) x word unit (onset / onset & vowel / rime / final consonant/s). The dependent variable was an accuracy score of the number of words read correctly out of 15. This total was a score from the 3 examples of each analogy unit nonword developed from each of 5 clue words in each word structure condition. For the real word error analysis a [3] (group) x (1) (real word errors) design was used. For the how many? error analysis a [3] (group) x 10 (error pattern category) design was used.

Results

Each participant generated 180 responses for pre-test and 180 responses for the post-test conditions. For the analysis of the number of correct responses a score of one was recorded for each nonword pronounced correctly. This analysis was conducted with a mixed factorial analysis of variance (ANOVA) with repeated measures on pre- and post-test, nonword structure, and orthographic analogy unit. Post-hoc analyses were conducted where applicable using Student Newman Keuls tests (SNK) with .05 taken as the level of significance. An analysis of error responses for percent of real word errors was also undertaken for all groups with a one-way ANOVA and SNK post-hoc tests. A further analysis of the error data was conducted for error pattern type. This included both real and nonword error responses. The CAM group was excluded from this analysis on the basis that they produced insufficient errors for these to be analysed as categories. All ANOVAs and post-hoc tests were conducted using *CSS Statistica*.

Analysis of the number of correct responses

The mean number of correct responses (out of a possible maximum correct score of 15) for each group at pre-test and post-test by nonword structure and word unit are presented in Table 2. Results from the 3[group] x 2(pre-/post-test) x 3(nonword structure) x 4(word unit) mixed factorial ANOVA (See Appendix D) showed a significant main effect for group, $F(2,42) = 34.78$, $p < 0.001$, in which all differences were found to be significant (SNKs, see Appendix D). As predicted the SRD group ($M = 6.99$) performed less accurately than the RAM group ($M = 10.98$) and both these groups performed lower then the CAM group ($M = 13.57$). A main effect was found for nonword structure, $F(2,84) = 16.81$, $p < 0.001$, with the children scoring significantly (SNK) higher on the CVC ($M = 11.37$) structure compared to both CVCC ($M = 10.05$) and CCVC ($M = 10.14$) on which the children's performance did not differ significantly. This did not support the prediction which stated that the CCVC structure would be more difficult to read. A main effect for pre-test and post-test was also found, $F(1,42) = 26.44$, $p < 0.001$, there being a significant improvement overall from pre-test ($M = 10.28$) to post-test ($M = 10.76$). No main effect for word unit was found. As there is no evidence to suggest a difference in reading difficulty of the constructed nonwords comparisons across the variables of pre-test/post-test and nonword structure are made easier.

Table. 2 Mean number of correct nonword responses and standard deviations (in parentheses) for each nonword structure and analogy unit condition as a function of reading group at pre- and post- test.

	Group					
	Specific Reading Disability		Reading-age Matched		Chronological-age matched	
Nonword structure & analogy condition	Pre-test	Post-test	Pre-test	Post-test	Pre-test	Post-test
CVC						
onset	9.33	9.20	11.93	12.4	14.27	14.27
	(3.29)	(3.26)	(2.52)	(2.32)	(1.09)	(1.33)
onset & vowel	8.60	8.53	11.13	11.87	13.73	14.20
	(2.99)	(2.92)	(2.82)	(2.72)	(1.33)	(0.94)
rime	7.80	8.53	10.73	11.53	13.87	14.33
	(2.48)	(2.29)	(3.43)	(3.23)	(1.55)	(1.55)
final consonant	8.33	6.73	11.47	12.47	14.07	13.67
	(3.56)	(2.89)	(2.03)	(2.19)	(0.88)	(1.39)
CVCC						
onset	6.27	6.13	10.07	11.00	12.00	12.93
	(2.49)	(3.27)	(2.94)	(2.93)	(2.53)	(1.91)
onset & vowel	5.27	5.80	9.53	10.87	12.40	13.13
	(2.76)	(2.88)	(3.55)	(3.14)	(2.77)	(1.88)
rime	6.60	7.00	10.80	11.87	13.80	14.46
	(3.39)	(3.12)	(2.43)	(2.26)	(1.32)	(0.83)
final consonants	5.93	6.00	11.20	11.67	13.13	13.40
	(3.39)	(2.59)	(2.51)	(2.61)	(1.46)	(1.68)
CCVC						
onset	6.93	7.27	9.80	10.87	13.07	13.73
	(3.63)	(3.45)	(3.85)	(3.50)	(1.79)	(2.02)
onset & vowel	6.47	7.40	9.53	11.00	13.87	14.33
	(3.83)	(3.85)	(3.25)	(3.83)	(1.64)	(1.23)
rime	5.95	5.67	10.47	11.20	13.27	13.60
	(3.57)	(3.15)	(3.91)	(4.02)	(1.94)	(1.99)
final consonants	6.07	6.03	9.53	10.80	12.93	13.53
	(3.17)	(3.75)	(3.07)	(3.45)	(2.12)	(1.81)

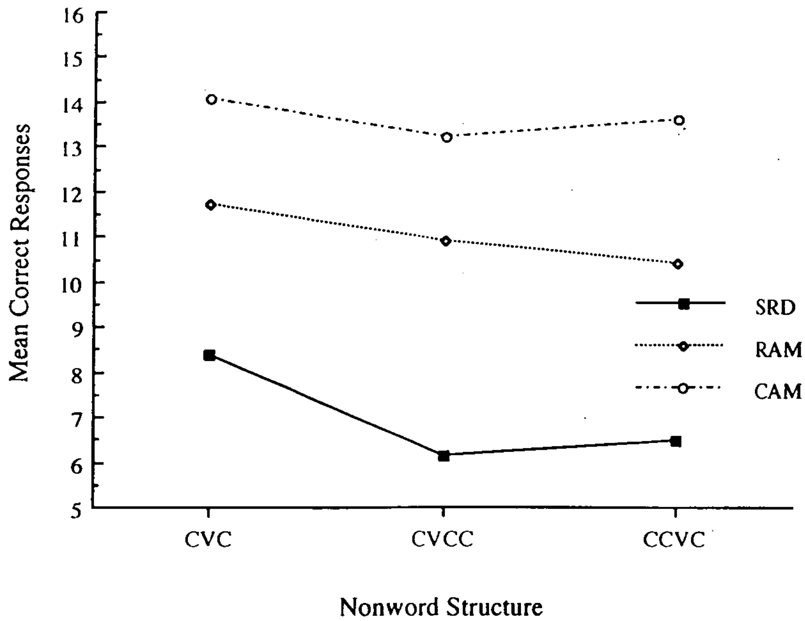

Figure 1. Mean correct responses for each group across nonword structure.

The interaction for group by nonword structure was not found to be significant with all groups scoring highest on CVC structure (see Figure 1). Means not given in Table 2 have been plotted in graphs to allow for comparison of derived means in the interactions. A significant interaction was found for the group by pre-test and post-test, $\underline{F}(2,42) = 7.59$, $p < 0.01$, and is shown in Figure 2 below. Post-hoc tests (SNKs) showed a significant improvement in number of nonwords read correctly from pre-test to post-test by the RAM group (pre-test $\underline{M} = 10.52$, post-test $\underline{M} = 11.46$) and also by the CAM group (pre-test $\underline{M} = 13.37$, post-test $\underline{M} = 13.78$). The means for the SRD group, however, did not differ significantly (pre-test $\underline{M} = 6.96$, post-test $\underline{M} = 7.02$).

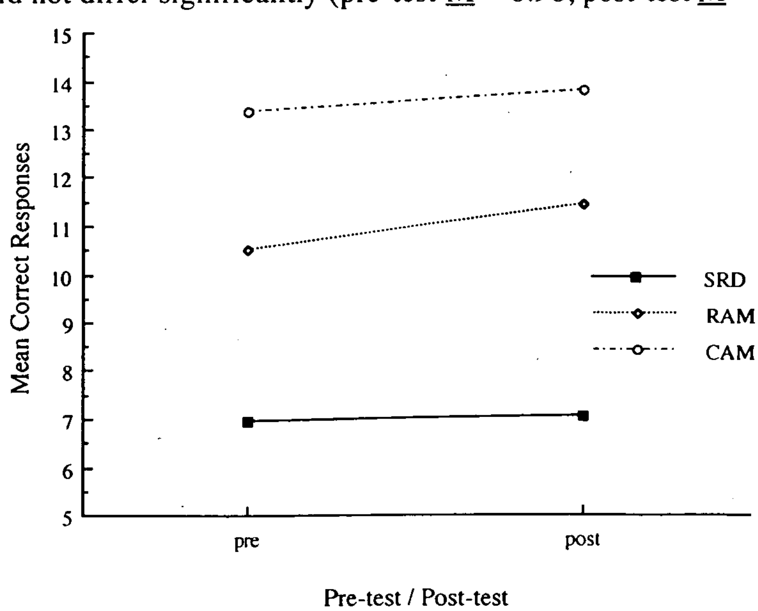

Figure 2. Mean correct responses for each group at pre-test and post-test.

The interaction between group and word unit was significant, $F(6,126) = 3.32$, $p < 0.01$. The interaction is shown in Figure 3. Post-hoc tests (SNKs) showed each group differed significantly from each other group on all of the word units. The CAM group scored significantly higher on all word units compared to both the RAM and SRD groups, and the RAM group scored significantly higher on all word units compared to the SRD group. No significant differences between scores for each word unit for the CAM and RAM groups were found. For the SRD group, however, there were significantly more nonwords read correctly which included the 'onset' word unit ($\underline{M}$ = 7.52) compared to all other word units ('onset and vowel' M = 7.01, 'rime' M = 6.92, 'final consonant/s' M = 6.52).

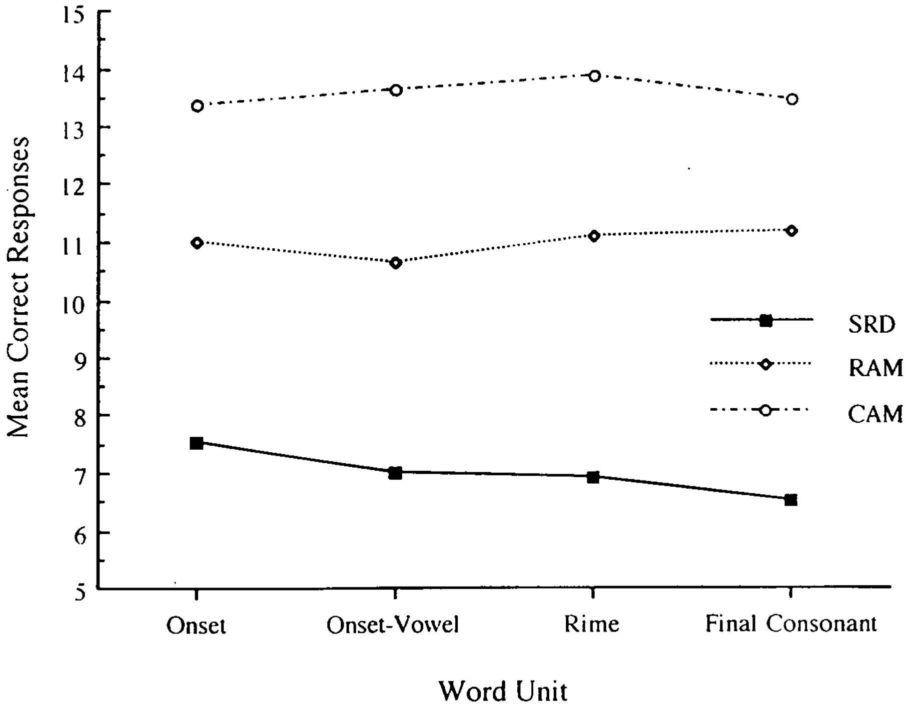

Figure 3. Mean correct responses for groups for each word unit.

A significant interaction between pre-test and post-test and nonword structure was also found, $\underline{F}(2, 84) = 3.69$, $p < 0.05$. The interaction is shown in Figure 4. Scores on the CVC nonword structure (pre-test $\underline{M}$ = 11.27, post-test $\underline{M}$ = 11.46) did not differ significantly (SNK) from pre- to post-test. This may have been due to the high level of initial correct responses. However, a significant improvement was noted for CVCC structure nonwords (pre-test $\underline{M}$ = 9.75, post-test $\underline{M}$ = 10.36), and also for the CCVC nonword structure (pre-test $\underline{M}$ = 9.82, post-test $\underline{M}$ = 10.46).

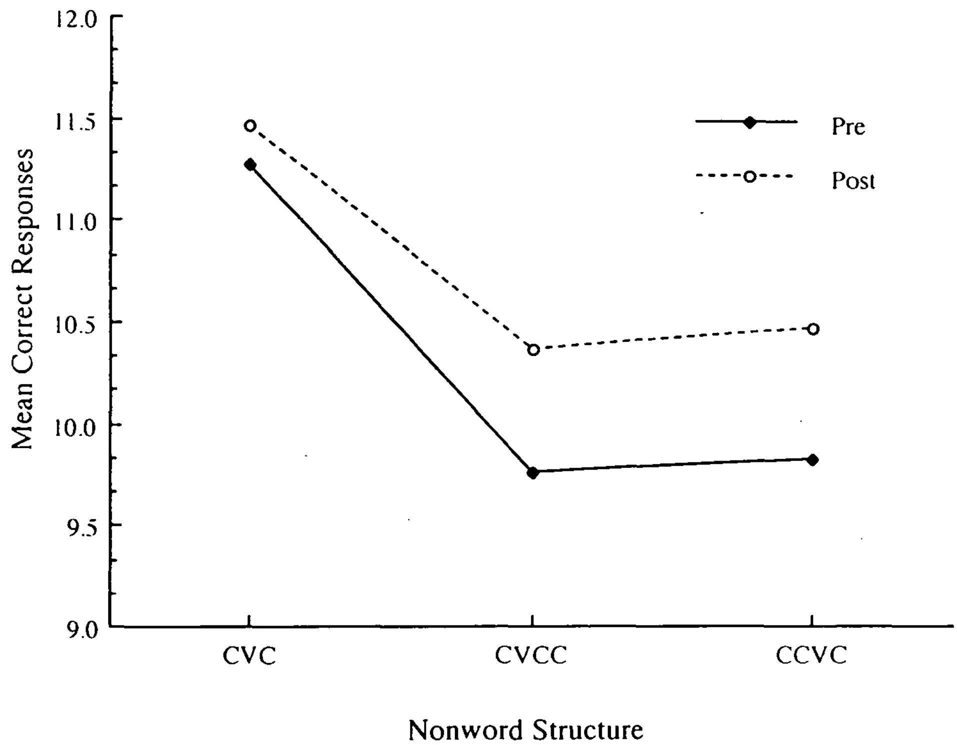

Figure 4. Mean correct responses at pre-test and post-test for each nonword structure.

A significant interaction was found for nonword structure by word unit, $\underline{F}(6,252) = 7.42$, $p < 0.001$. Means are plotted in Figure 5. For the CVC nonword structure the nonwords including the 'onset' word unit ($\underline{M} = 11.9$) were read correctly significantly (SNKs) more often than nonwords including all other word units which did not differ significantly from each other ('onset and vowel' $\underline{M} = 11.34$, 'rime' $\underline{M} = 11.1$, 'final consonant/s' $\underline{M} = 11.12$). In the CVCC structure nonwords including the 'rime' word unit ($\underline{M} = 10.76$) were read correctly significantly more often than nonwords including all other word units apart from the 'final consonant/s' unit ($\underline{M} = 10.22$) which was also read correctly significantly more often compared to the 'onset and vowel' unit ($\underline{M} = 9.5$) but not the 'onset' unit ($\underline{M} = 9.73$). No other differences were significant. No differences were found to be significant between the word units in the CCVC nonword structure.

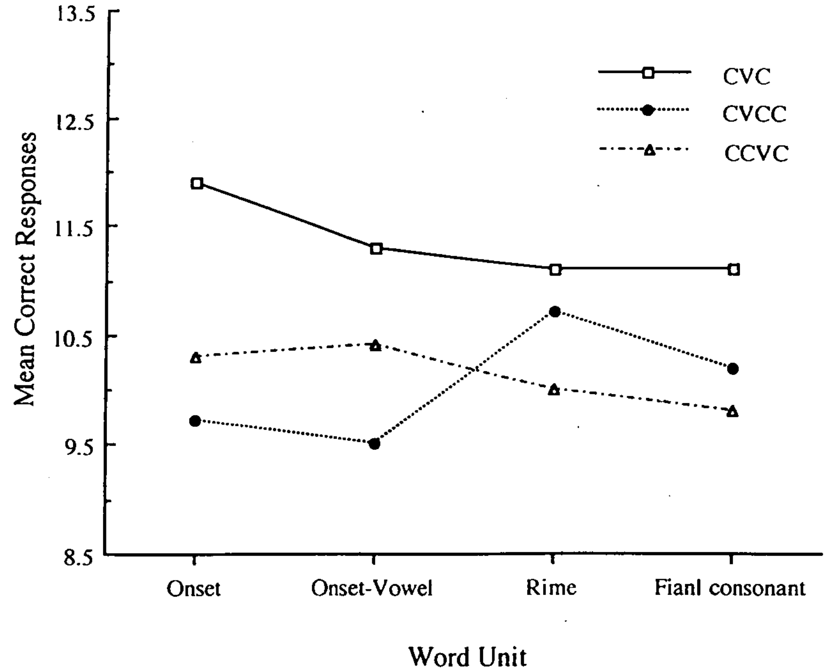

Figure 5. Mean correct responses by nonword structure at each word unit.

The interaction for pre-test/post-test and word unit, shown in Figure 6, was significant, $\underline{F}$ (3,126) = 2.82, $p < 0.05$. Significant differences (SNK) were found between pre- and post-test for nonwords including the word units 'onset' (pre-test $\underline{M}$ = 10.4, post-test $\underline{M}$ = 10.87), 'onset and vowel' (pre-test $\underline{M}$ = 10.06, post-test $\underline{M}$ = 10.8), and for 'rime' (pre-test $\underline{M}$ = 10.36, post-test $\underline{M}$ = 10.89). No significant difference was found between pre- and post-test for the 'final consonant/s' unit (pre-test $\underline{M}$ = 10.29, post-test $\underline{M}$ = 10.48). No three-way interactions were found to be significant nor was the interaction for all variables.

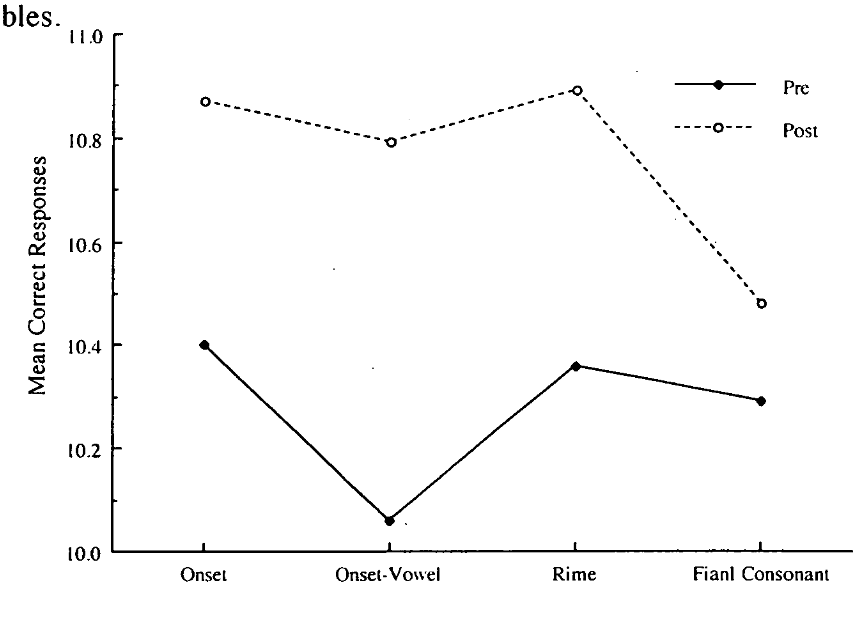

Figure 6. Mean correct responses at pre-test and post-test for word unit.

Error Analysis

Analysis of real word errors

To investigate possible differences in reading strategy by each group, error responses were initially classified as real or nonwords and an analysis of error responses was performed on the percent of real word error responses for each group across all responses. Mean percent of real word errors for each group are presented in Table 3.

Table 3. Percent of real word error responses for each group.

Group	M	SD
SRD	44.89	8.24
RAM	41.62	11.29
CAM	32.31	19.34

As the data for error pattern categories is proportional in nature an arc-sine transformation was considered for the analysis of variance. However, as suggested by Milligan (1987) the application of the transformation has no effect on the Type 1 error rate and poses interpretational problems for the researcher. Furthermore it has been demonstrated that the ANOVA procedure is relatively insensitive to failure to meet its assumptions (Pagano, 1990).

Results from the one-way ANOVA (See Appendix E) showed a significant difference between the groups on percent of real word errors made, $F(2,42) = 3.37$, $p < 0.05$. However, post-hoc analyses (SNK, see Appendix E) showed the SRD group and RAM group did not differ significantly in percent of real word errors, whilst the SRD group made significantly more real word errors than the CAM group. The difference between the RAM and CAM groups, although appearing large was not significant, $p = 0.071$.

Analysis of error responses by error pattern categories

To investigate further any qualitative differences in response patterns, and salience of particular word segments for each group, both real and nonword error responses were classified according to the secondary categories outlined in Table 4. Each response was classified under only one of these categories. The mean number of

Table. 4. Error pattern categories and definitions

Error Categories	Definition of Categories
Primary Category*	
Incorrect nonword	A response was scored as an incorrect nonword in cases where it was not found in the Collins English Dictionary (1992), when from another language, classified archaic, or not in common usage in Australian English. A decision was made to comply with the focus of this paper (ie., orthographic analogies), that in scoring a response as a real or nonword where the response included letters from the target word these would be transcribed as in the target. For example, if the target were '*hox*' and the response '*nox*' (a nonword), it would be scored as such, and not as '*knocks*' (a real word).
Real word response	A response is scored as a real word if it was included in the Collins English Dictionary (1992), excluding those responses classified as from another language, archaic, or not in common usage in Australian English.
Secondary Categories	
Under 50% similarity	Under 50% of the target word letters are included in the response and the response cannot be scored under any other category. (e.g., *rab-best*)
Onset only	The onset only of the target word is the onset of the response, the rime is not the same. For example, *skom-skin, ved-veen, pob-prumpel.*
Onset and vowel only	The onset and the vowel only are included in the response. For example, *glun-glup, stum-stult.*
Rime only	The rime only of the target is included in the response. For example, *zond-pond, drut-vut.*
Final consonant only	The final letter only is included in the response in the same position. For example, *smum-droem, pob-hab.*
Beginning and final	Includes responses where the beginning and final consonants or consonant clusters of the target are in the same positions in the response It includes a vowel change plus either a consonant cluster reduction, insertions or substitutions. For example, *skut-sot, pud-plod, hult-host.*
Vowel change	Includes changes of vowel and lengthening of the vowel. For example, *fram-frame, bram-breem.*
Consonant cluster reductions	Responses include an omission of a consonant in a consonant cluster. For example, *lamp-lap, frot-fot.*
Letter insertion	Includes responses in which one or more letters have been inserted into the target word. For example, *vot-volt, hod-hored.*
50% or greater similarity	Includes responses which do not fit any of the above categories but include 50% or more of the target letters (e.g., *skom-smoke*) Included are partial and whole word reversals (e.g., *mab-bam*) and change of cluster positions (e.g., *polt-plot*).

* Note. Each individual response was scored as correct or incorrect. Errors were then scored as being a real word or nonword response. Each error response was then given a second classification according to error pattern categories. Each response was included only once in a primary and once in a secondary category.

errors in each category for SRD and RAM groups are pictured in Figure 7. The CAM group was excluded from this analysis as their number of error responses was insufficient to analyse under categories. Mean numbers of errors were used rather than proportions. Clearly, as the previous analysis showed a main effect for the number of correct responses, a main effect for the number of errors was expected. However this was not of direct interest. Instead the purpose was to determine whether there was an interaction effect as this would indicate that different strategies were being used by the groups.

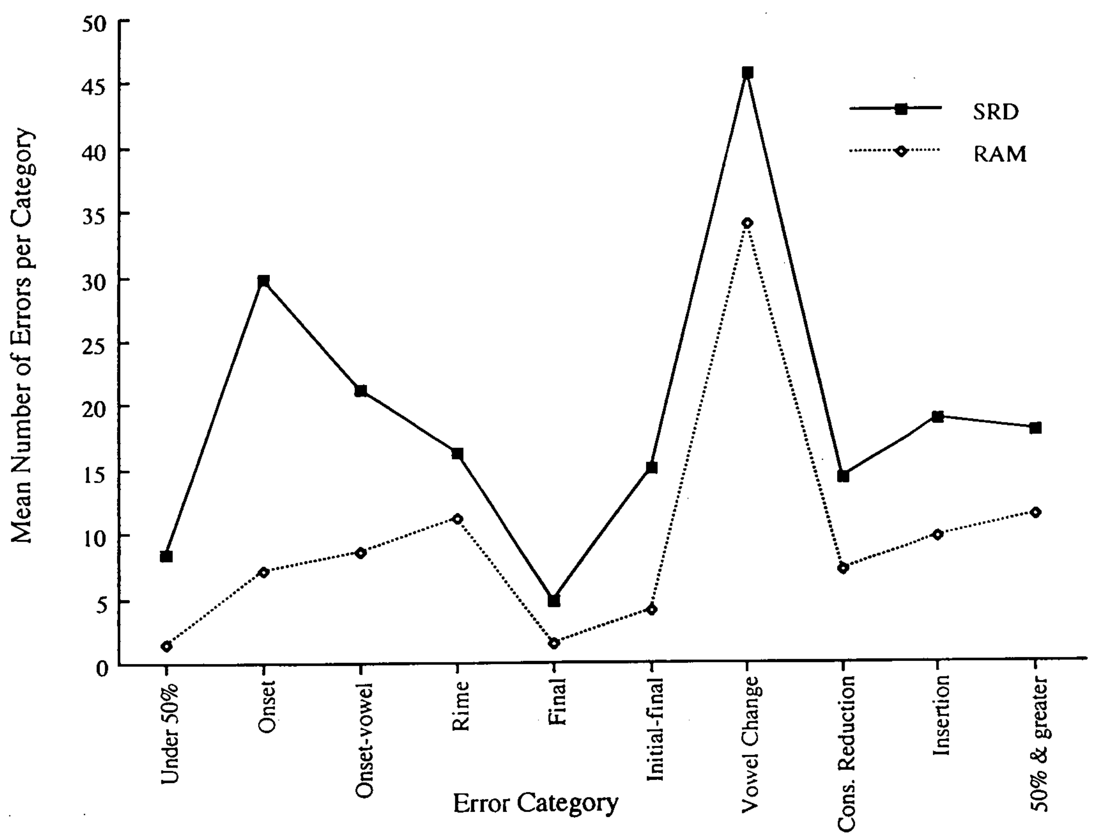

Figure 7. Mean number of error responses in each category for the RAM and SRD groups.

A two-way ANOVA (See Appendix F) showed a significant main effect for group $\underline{F}(1, 28) = 18.8$, $p < 0.001$. It The SRD ($\underline{M} = 19.18$) group giving significantly more error responses overall compared to the RAM group ($\underline{M} = 9.6$). A main effect also occurred for the error pattern categories $\underline{F}(9, 252) = 26.63$, $p < 0.001$. Across both groups, the greatest number of errors occurred in the 'vowel change' category ($\underline{M}$ = 39.8), followed by 'onset only' ($\underline{M}$ = 18.36), 'onset and vowel' ($\underline{M}$ = 14.86), '50% or greater similarity' ($\underline{M}$ = 14.57), 'letter insertion' ($\underline{M}$ = 14.3), 'rime' ($\underline{M}$ = 13.73), 'consonant cluster reduction' ($\underline{M}$ = 10.7), 'beginning and final' ($\underline{M}$ = 9.5), 'under 50% similarity' ($\underline{M}$ = 4.96), and 'final letter only' ($\underline{M}$ = 3.13).

The interaction for group by error pattern category was significant $\underline{F}(9, 252) = 1.95$, $p < 0.05$. Post-hoc analyses (SNKs, see Appendix F) showed the groups to be significantly different at the categories of 'onset only' (SRD $\underline{M}$ = 29.67, RAM $\underline{M}$ = 7.06), 'onset and vowel' (SRD $\underline{M}$ = 21.13, RAM $\underline{M}$ = 8.6), and 'vowel change' (SRD $\underline{M}$ = 45.67, RAM $\underline{M}$ = 33.93). No other differences between the groups on error pattern category were found to be significant. Post-hoc tests also showed there to be no significant differences between the number of errors in each category for the RAM group apart from the 'vowel change' category in which there was a significantly greater number of errors compared to all other categories. The pattern of error responses for the SRD group differed to this, in that whereas there were significantly more errors in the 'vowel change' category than any other category, there were also significantly more errors in the 'onset only' category than any other category (apart from the 'vowel change' category). The 'final consonant' category ($\underline{M}$ = 4.73) had significantly fewer errors than the 'onset and vowel', 'letter insertion' ($\underline{M}$ = 18.86), and '50% or greater similarity' categories ($\underline{M}$ = 17.86). The 'under 50% similarity' category ($\underline{M}$ = 8.46) also had significantly fewer errors than the 'onset and vowel' category.

Discussion

The hypothesis that children with an SRD would perform below the RAM group, and that the RAM group would perform below the CAM group on nonword reading overall was supported. It is assumed that nonwords will not have been seen before and so must be read via phonological decoding at some level rather than via a direct lexical access. Some researchers have found that children with an SRD do not differ significantly in their ability to read nonwords relative to children of a similar reading age (e.g., Szeszulski & Manis, 1987; Treiman & Hirsh-Pasek, 1985). However, the findings of the present study support research which suggests that a phonological deficit in children with an SRD will cause lower performance in reading nonwords relative to both children of the same chronological age and younger children with the same reading age (e.g., Snowling, 1980; Siegel & Ryan, 1988).

The main finding of this experiment is that the groups differed in their performance from pre-test to post-test. Both the RAM and CAM groups showed a significant increase in performance from pre-test to post-test whereas the SRD group showed no increase. This finding supports research which has found no use of analogy in children with an SRD (e.g., Manis et al., 1986; Lovett et al., 1990). Thus, the SRD group did not benefit from the availability of a clue word on which to base orthographic analogy, even when this word was present and the nonwords were of a simple structure. The majority of research which has found a benefit from the use of an orthographic analogy strategy in children with an SRD has investigated training in this strategy (e.g., Gaskins et al., 1988; Wolff et al., 1985; van Daal et al., 1994). It may be the case that children with an SRD do not spontaneously use an orthographic analogy strategy but training in the strategy may be effective. Although the RAM and CAM groups showed a significant increase from pre-test to post-test this effect was smaller than other effects and the possibility that this was due simply to a second reading of the words cannot be discounted as no real control condition was used in the word unit variable. No three-way interaction occurred between group, pre-test/post-test, and word unit. It was predicted that such an interaction would occur if there was a difference between the groups in the availability of the different word units. Due to the lack of a three-way interaction there is no evidence to suggest any differential use of word units across pre- and post-test conditions as previously found by Goswami (1993).

The finding of a significant interaction between group and word unit can be accounted for by the SRD group performing better on nonwords which included the 'onset' unit. This may be due to the children with an SRD partially decoding nonwords using the initial consonant to guess at the rest of the word and so being more likely to produce a correct response when the nonword had the same onset as the clue word from which it was derived.

The effect of nonword structure did not differ between the groups, the CVC structure being easiest for all groups, and no significant difference was found between CVCC and CCVC for all groups. This is contrary to findings which suggest that children with an SRD find consonant clusters in the initial position to be especially difficult (Lewkowiscz, 1980). However, Snowling (1981) has argued that this difficulty may exist only for more phonologically complex two-syllable words.

The significant interaction between nonword structure and pre-test/post-test is accounted for by there being an initially high performance on the CVC structure and thus performance on this nonword structure showed less improvement than the other structures. Performance across all groups on the analogy transfer units from pre-test to post-test differed according to the unit. As the SRD group did not show an increase in performance from pre-test to post-test the effect is due to the performance of the RAM and CAM groups. There was a significant increase in performance from pre-test to post-test on words which included the onset, onset and vowel, and the rime, but not for the final consonant/s. This finding is in agreement with results from Goswami (1986, 1993). Goswami found that beginning readers are most able to make use of onset and rime units as units for transfer and that slightly older readers will also use onset and vowel units. She suggests that as reading develops the phonological underpinning of orthographic units is no longer restricted to onset-rime units. A more refined phonological underpinning is assumed to develop, which takes account of other graphemes or grapheme clusters. As the results for the present study did not show a three-way interaction between group, pre-test/post-test and analogy transfer unit, it is not possible to postulate further as to the basis for the difference in performance across pre- and post-test on the analogy units. However, it may be the case that the RAM and CAM groups differed in which units were of most benefit.

Error patterns were examined in this study to ascertain whether the groups differed in strategies they used to assemble pronunciations for nonwords. Different distributions in error patterns may indicate qualitative differences between the groups in strategies for reading. Research which has analysed the error types made by children with an SRD has found that they respond with a higher proportion of real word errors when compared to reading-age matched groups (e.g., Treiman & Hirsh-Pasek, 1985). Siegel (1986) also found that children with an SRD often read nonwords as real words and also substitute one real word for another. She argues that these children are attempting to use an analogy strategy but, as they have difficulties in the phonological skills of segmenting and blending which are necessary to a limited extent in the use of analogy, they are unsuccessful. Siegel (1993) suggested that her data support a phonological deficit hypothesis of the aetiology of dyslexia. The present study did not find a significant difference between the SRD and RAM groups in the percent of real word errors made which is similar to the results found by Manis et al. (1986). This suggests that although the SRD performs lower overall on nonword reading than the RAM group the error pattern for real and nonword responses is similar, leading to the possible conclusion that their strategy use may be similar.

However, further analysis of error patterns did not support this conclusion. Previous research on error patterns in beginning readers has found that vowels generate more errors than consonants (Fowler, Liberman, & Shankweiler, 1977; Treiman et al., 1990). The present research supports these findings as it was found that both the RAM and SRD groups produced significantly more errors in this category than any other. Further, for the RAM group this was the only category which showed a difference in the amount of errors compared to any other error pattern category. An error analysis performed by Walton (1995) on incorrect responses to letter-sound reading test words similarly found that most errors occurred on the medial vowel. Walton has proposed that it is this ability to identify initial and especially final phonemes that is strongly related to analogy word reading. He suggests that the final phoneme, represented in orthography by the final letter, plays the primary role in determining the sound of the rime ending. Thus, children using an analogy strategy "may not differentiate the phonological representation of the final letter from the rime .... [and so] may not use the information that the medial vowel is what distinguishes *-ed* from *-ad*" (Walton, 1995, p. 595). The results of the present study also showed significantly fewer errors in the 'final consonant only' category than any other category for the SRD group, suggesting that ability to identify final phonemes may be particularly deficient in children with an SRD. Clearly further investigation of this needs to occur as this deficit may hamper the ability to use analogy strategies.

Research also supports a letter position effect in which errors occur more frequently on consonants in a final position than in the initial position (e.g., Fowler, Liberman & Shankweiler, 1977; Mosckicki & Tallal, 1981). The analysis of error patterns for the RAM group did not show this effect. However, the response pattern for the SRD group suggests that more errors occurred in the final rather than the initial position, showing a response pattern similar to beginning readers (Mosckicki & Tallal, 1981), rather than readers with some experience. Wolff et al. (1985) found that this 'partial decoding' (using only a first letter or two) is most common in disabled readers. Venezky (1976) also found that, whereas children with an SRD did not differ from average readers in their ability to read consonants in an initial position correctly, there were large differences when the consonants occupied medial and final positions. Venezky (1976) claims that the problem is not one of a lack of letter-sound awareness but a tendency not to analyse the interior components of words. Stanovich (1992) suggests that this may be due to a problem in the formation of orthographic representations. The results from the present study, in agreement with Wolff et al. (1985) and Venezky (1976), also show what may be an over-reliance on the initial consonants in a word as a large number of errors included the initial consonant/s whilst few included the final consonant/s.

Seidenberg, Bruck, Fornarolo, and Backman (1985), found that the distribution of errors in their study did not provide support for the hypothesis that children with an SRD were using decoding processes that were qualitatively different from other groups, nor did they find any idiosyncratic pattern of errors for the SRD group. They argue that their error data reflect different levels of competence rather than different strategy use between the groups. Hence they suggest their data supports a developmental delay among children with an SRD. The results from the present study, however, do not support Seidenberg et al.'s (1985) conclusion. Although no difference was found between the RAM and SRD groups on the proportion of real word error production, there was a difference in the pattern of errors made. Therefore, it is suggested that there may not simply be a developmental delay in children with an SRD but that they appear to be using, or attempting to use, different strategies for reading compared to children of a similar reading age.

The fact that children with an SRD do not appear to benefit from the availability of a clue word on which to base analogy may be due to an initial deficit in rhyme awareness (Bradley & Bryant, 1978), and therefore a consequent failure of this to be linked to orthographic units which correspond to the phonological units. The results of the error analysis support the proposal by Venezky (1976) that children with an SRD fail to note the internal structure of a word and rely on the partial decoding (Wolff et al., 1985) of the first letter or two on which to guess at the rest of the word. This of course necessitates some level of phonological awareness (Stuart & Coltheart, 1988). Thus, it is argued that, although children with an SRD have a deficit in phonological awareness, it is not complete. If it is the case that children with an SRD have an initial deficit in rhyme awareness, considered a prerequisite for reading, then it may be that there is a failure to link the phonological rime unit with orthographic rime units. Recent studies (e.g., Stahl & Murray, 1994; Walton, 1995) suggest that the development of this link is necessary for the use of orthographic analogy as a reading strategy and for later reading success. Clearly longitudinal studies are necessary to clarify a link between pre-school rhyme awareness and orthographic analogy use in both normal and disabled readers.

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APPENDIX A

Descriptive data and raw scores for all participants

Table. 1 Descriptive data and raw scores for all participants on chronological-age, sex, and Neale-R accuracy, rate & comprehension.

descriptive data							
					NEALE-R scores		
Group	Subject number	gender	chronological age (CA)-in months.	RA from CA in months	accuracy (RA)	rate	comprehension
srd	1	m	100	-24	76	72	89
srd	2	f	108	-34	74	72	75
srd	3	m	118	-24	94	90	94
srd	4	m	117	-24	93	102	113
srd	5	f	127	-38	89	151	108
srd	6	m	125	-31	94	90	111
srd	7	m	120	-43	77	146	91
srd	8	m	126	-51	75	128	73
srd	9	m	118	-30	88	72	86
srd	10	m	104	-29	75	72	80
srd	11	m	110	-24	86	72	97
srd	12	m	115	-24	91	91	97
srd	13	f	116	-24	92	90	97
srd	14	m	106	-34	72	72	75
srd	15	f	122	-31	91	86	140
ram	16	f	81	9	89	72	83
ram	17	f	81	12	93	74	78
ram	18	m	82	5	87	92	86
ram	19	m	92	-1	91	93	80
ram	20	m	93	-1	92	72	83
ram	21	m	87	2	89	110	89
ram	22	m	88	5	93	92	80
ram	23	f	91	2	93	97	86
ram	24	m	93	2	95	118	102
ram	25	m	77	0	77	72	86
ram	26	m	73	2	75	72	78
ram	27	m	73	0	73	72	72
ram	28	m	71	1	72	72	72
ram	29	m	76	-1	75	72	83
ram	30	m	79	-1	78	72	75
cam	31	m	108	4	112	137	125
cam	32	m	110	2	112	83	116
cam	33	f	109	6	115	100	111
cam	34	m	114	0	114	115	89
cam	35	m	105	3	108	72	100
cam	36	f	104	4	108	93	97
cam	37	m	104	9	111	77	111
cam	38	m	118	1	119	120	92
cam	39	f	128	3	131	151	122
cam	40	f	114	1	115	118	94
cam	41	f	122	5	127	131	87
cam	42	f	119	4	123	119	83
cam	43	m	118	0	118	72	94
cam	44	m	132	11	143	140	138
cam	45	f	110	7	117	128	125

Table. 2 WISC-III subtest standard scores and deviation quotients for all participants .

			WISC-III subtests			
Group	Subject number	D.Q.[a]	PC	BD	SIM	VOC
srd	1	113	13	19	9	8
srd	2	108	11	14	9	11
srd	3	120	16	15	13	9
srd	4	122	16	18	11	9
srd	5	118	16	18	10	7
srd	6	114	10	16	13	10
srd	7	103	12	11	13	6
srd	8	86	9	9	7	5
srd	9	105	11	15	8	9
srd	10	103	11	19	9	13
srd	11	116	12	15	13	10
srd	12	101	11	9	11	9
srd	13	95	9	13	8	7
srd	14	89	10	9	7	7
srd	15	94	10	11	10	5
ram	16	114	12	14	12	10
ram	17	115	10	19	10	10
ram	18	135	17	12	14	18
ram	19	110	14	11	13	9
ram	20	89	7	8	9	9
ram	21	123	12	19	12	11
ram	22	103	13	14	8	7
ram	23	123	13	19	12	10
ram	24	117	14	19	9	8
ram	25	102	11	9	12	9
ram	26	105	8	9	13	13
ram	27	106	10	12	13	9
ram	28	114	9	12	16	12
ram	29	98	8	11	11	9
ram	30	92	9	7	9	10
cam	31	121	11	19	14	9
cam	32	124	10	19	14	12
cam	33	98	9	12	10	8
cam	34	100	10	12	9	9
cam	35	103	13	12	7	10
cam	36	103	13	11	9	9
cam	37	122	15	17	12	11
cam	38	89	11	9	6	7
cam	39	108	12	11	14	8
cam	40	109	13	11	13	9
cam	41	105	10	10	13	10
cam	42	86	8	10	7	6
cam	43	103	10	14	9	9
cam	44	119	15	13	14	10
cam	45	111	14	8	14	11

Note. D.Q. = deviation quotient, PC = picture completion, BD = block design, SIM = similarities, VOC = vocabulary.

[a] = deviation quotient was calculated on the basis of the subtests; picture completion, block design, similarities, and vocabulary.

APPENDIX B

One-way ANOVAs and Descriptive Statistics for group matching variables.

Appendix B *One-way Analyses of variance for matched variables of chronological-age, reading-age and IQ deviation quotients.*

Table. 1
One-way Analysis of variance for group (SRD and CAM) by chronological age in months.

Main effect - Group					
Univar. test	Sum of squares	df	Mean square	F	p-level
Effect	9.633	1	9.63333	0.136708	0.714358
Error	1973.067	28	70.46667		

	Descriptive statistic	
Group	M	SD
SRD	115.466	8.279
CAM	114.333	8.507

Table. 2
One-way Analysis of variance for group (SRD and RAM) by reading age in months.

Main effect - Group					
Univar. test	Sum of squares	df	Mean square	F	p-level
Effect	0.833	1	0.8333	0.011426	0.915637
Error	2042.133	28	72.9333		

	Descriptive statistic	
Group	M	SD
SRD	84.467	8.467
RAM	84.800	8.612

One-way Analyses of variance for matched variables of chronological-age, reading-age and IQ deviation quotients. ***(Cont.)***

Table 3
One-way Analysis of variance for group (SRD and CAM) by estimated WISC-III full-scale IQ-deviation quotient.

Main effect - Group					
Univar. test	Sum of squares	df	Mean square	F	p-level
Effect	6.55	1	6.533	0.050376	0.824040
Error	3631.333	28	129.691		

	Descriptive statistic	
Group	M	SD
SRD	105.800	11.37164
CAM	106.733	11.40468

Table. 4
One-way Analysis of variance for group (SRD and RAM) by estimated WISC-III full-scale IQ-deviation quotient

Main effect - Group					
Univar. test	Sum of squares	df	Mean square	F	p-level
Effect	116.033	1	116.033	0.824323	0.371668
Error	3941.333	28	140.7619		

	Descriptive statistic	
Group	M	SD
SRD	105.800	11.372
RAM	109.733	12.337

APPENDIX C

Clue word and Nonword Stimuli

Table. 1
Clue word and nonword stimuli of a CVC construction used in experiment.

	Onset	Onset + vowel	Rime	Final consonant
Clue word	Cvc	CVc	cVC	cvC
PAT[a]	pob	pag	jat[a]	fut[a]
	pid	pab	lat[a]	vot
	pum	pas[a]	gat[a]	mit
HEM	hud	het[a]	kem	zim
	hig	hep	sem	gom
	han[a]	heb	bem	wum
LID	lod	lim	nid	pud
	lup	lig	fid	ved
	leb	lin	wid	dod
HOP	hax	hon	dop	fap
	heg	hox	jop	lep
	hin	hom	zop	bup
RUB	rab	rup	mub	jeb
	rit	rud	jub	mab
	rop	rux	gub	kib

Note. All clue words and onwords not otherwise specified have consistent and regular pronunciations.

[a] = Rime spellings in English which have variant vowel pronunciations (e.g., at may be pronounced as in hat or what).

Table. 2
Clue word and nonword stimuli of a CVCC structure used in experiment.

	Onset	Onset + vowel	Rime	Final consonant
Clue word	Cvcc	CVcc	cVCC	cvCC
LAMP	lisk	lant[a]	gamp	femp
	lelf	lask[b]	tamp	himp
	lult	laft[b]	jamp	nump
RISK	rund	rimp	tisk	fask[b]
	ront	rilt	misk	besk
	remp	rint[a]	gisk	kusk
HUNT	hamp	hult	dunt	gant[a]
	hosk	hulp	munt	lont[b]
	hilk	huct	vunt	wint[a]
NEST	nank	nend	sest	tist
	nulp	nemp	dest	bast[b]
	nilk	nelf	mest	wost[a]
POND	pamp	pold[b]	zond	tund
	peft	polt[b]	hond	gand
	pilt	poft	gond	nind[a]

Note. All clue words and nonwords not otherwise specified have consistent and regular pronunciations.

[a] = Rime spellings in English which have variant vowel pronunciations (e.g., ind may be pronounced as in wind or kind).

[b] = Rime spellings in English in which vowel pronunciation is consistent but not regular (e.g., ont which is always pronounces as in front, but the vowel sound is not the regular sound for o in closed syllables).

Table. 3
Clue word and nonword stimuli of a CCVC srtucture used in experiment.

Clue word	Onset CCvc	Onset + vowel CCVc	Rime ccVC	Final consonants ccvC
SKIN	skom	skib	prin	fren
	skeb	skig	clin	glun
	skup	skix	trin	cran[a]
DRUM	dren	drup	smum	swem
	drap	drut[a]	stum	plam
	drid	drux	clum	snim
STEM	stap	stex	drem	blom
	stin	steg	glem	prum
	stug	steb	brem	fram
TRAP	trub	trad	glap	clup
	trom	tran[a]	skap	blop
	treg	trab	smap	swep
PLOT	plix	plom	frot	grat[a]
	plun	plog	crot	dret[a]
	plep	plob	smot	skut[a]

Note. All clue words and nonwords not otherwise specified are closed syllables with consistent and regular pronunciations.

[a] = Rime spellings in English which have variant vowel pronunciations (e.g., ut may be pronounced as in glut or put).

APPENDIX D

Four-way ANOVA summary of all effects, mean scores, and Student Newman Keuls tests.

Appendix D. *Four-way Analysis of variance for group, nonword structure, pre-test/post-test, and orthographic transfer unit for number of correct responses.*

Table 1.

Four-way ANOVA, summary of all effects (Where 1 = group, 2 = nonword structure, 3 = pre-test/post-test, 4 = orthographic transfer unit).

General Manova	Summary of all effects											
Effect	df effect		MS effect		df Error		MS Error		F		p - level	
1	2	*	3956.84	*	42	*	113.77	*	34.78	*	.0000	*
2	2	*	194.47	*	84	*	11.56	*	16.81	*	.0000	*
3	1	*	61.16	*	42	*	2.31	*	26.43	*	.0000	*
4	3		4.59		126		2.94		1.55		.2028	
12	4		28.34		84		11.56		2.45		.0523	
13	2	*	17.57	*	42	*	2.31	*	7.59	*	.0015	*
23	2	*	5.58	*	84	*	1.51	*	3.69	*	.0288	*
14	6	*	9.77	*	126	*	2.94	*	3.31	*	.0045	*
24	6	*	21.19	*	252	*	2.85	*	7.42	*	.0000	*
34	3	*	3.45	*	126	*	1.22	*	2.82	*	.0414	*
123	4		.33		84		1.51		.22		.9261	
124	12		2.80		252		2.85		.98		.4677	
134	6		.98		126		1.22		.80		.5688	
234	6		1.72		252		1.43		1.20		.3052	
1234	12		1.20		252		1.43		.84		.6080	

Appendix D *(cont.)*

Table 2.

Means for number of correct nonword responses at each condition for SRD, RAM, and CAM groups.

Group	nonword structure	pre-test/ post-test	analogy unit	M correct responses	SD
SRD	CVC	pre	onset	9.333	3.29
	CVC	pre	onset-vowel	8.600	2.99
	CVC	pre	rime	7.800	2.48
	CVC	pre	final	8.333	3.56
	CVC	post	onset	9.200	3.26
	CVC	post	onset-vowel	8.533	2.92
	CVC	post	rime	8.533	2.29
	CVC	post	final	6.733	2.89
	CVCC	pre	onset	6.266	2.49
	CVCC	pre	onset-vowel	5.266	2.76
	CVCC	pre	rime	6.600	3.39
	CVCC	pre	final	5.933	3.39
	CVCC	post	onset	6.133	3.27
	CVCC	post	onset-vowel	5.800	2.88
	CVCC	post	rime	7.000	3.12
	CVCC	post	final	6.000	2.59
	CCVC	pre	onset	6.933	3.63
	CCVC	pre	onset-vowel	6.466	3.83
	CCVC	pre	rime	5.933	3.57
	CCVC	pre	final	6.066	3.17
	CCVC	post	onset	7.266	3.45
	CCVC	post	onset-vowel	7.400	3.85
	CCVC	post	rime	5.666	3.15
	CCVC	post	final	6.066	3.75

Group	nonword structure	pre-test/ post-test	analogy unit	M correct responses	SD
RAM	CVC	pre	onset	11.933	2.52
	CVC	pre	onset-vowel	11.133	2.82
	CVC	pre	rime	10.733	3.43
	CVC	pre	final	11.466	2.03
	CVC	post	onset	12.400	2.32
	CVC	post	onset-vowel	11.866	2.72
	CVC	post	rime	11.533	3.23
	CVC	post	final	12.466	2.19
	CVCC	pre	onset	10.066	2.94
	CVCC	pre	onset-vowel	9.533	3.55
	CVCC	pre	rime	10.800	2.43
	CVCC	pre	final	11.200	2.51
	CVCC	post	onset	11.000	2.93
	CVCC	post	onset-vowel	10.866	3.14
	CVCC	post	rime	11.866	2.26
	CVCC	post	final	11.666	2.61
	CCVC	pre	onset	9.800	3.85
	CCVC	pre	onset-vowel	9.533	3.25
	CCVC	pre	rime	10.466	3.91
	CCVC	pre	final	9.533	3.07
	CCVC	post	onset	10.866	3.50
	CCVC	post	onset-vowel	11.000	3.83
	CCVC	post	rime	11.200	4.02
	CCVC	post	final	10.800	3.45

Group	nonword structure	pre-test/ post-test	analogy unit	M correct responses	SD
CAM	CVC	pre	onset	14.266	1.09
	CVC	pre	onset-vowel	13.733	1.33
	CVC	pre	rime	13.866	1.55
	CVC	pre	final	14.066	0.88
	CVC	post	onset	14.266	1.33
	CVC	post	onset-vowel	14.200	0.94
	CVC	post	rime	14.133	1.55
	CVC	post	final	13.666	1.39
	CVCC	pre	onset	12.000	2.53
	CVCC	pre	onset-vowel	12.400	2.77
	CVCC	pre	rime	13.800	1.32
	CVCC	pre	final	13.133	1.46
	CVCC	post	onset	12.933	1.91
	CVCC	post	onset-vowel	13.133	1.88
	CVCC	post	rime	14.466	0.83
	CVCC	post	final	13.400	1.68
	CCVC	pre	onset	13.066	1.79
	CCVC	pre	onset-vowel	13.866	1.64
	CCVC	pre	rime	13.266	1.94
	CCVC	pre	final	12.933	2.12
	CCVC	post	onset	13.733	2.02
	CCVC	post	onset-vowel	14.333	1.23
	CCVC	post	rime	13.600	1.99
	CCVC	post	final	13.533	1.81

Appendix D (cont.) *Student Newman Keuls tests for main effects and significant interactions.*

Table 3. Probabilities for post-hoc Student Newman-Keuls tests for group main effect.

	Probabilities for post-hoc tests for group main effect.	
Group	SRD	RAM
RAM	.000126	-
CAM	.000118	.002385

Table 4. Probabilities for post-hoc Student Newman-Keuls tests for nonword structure main effect.

	Probabilities for post-hoc tests for nonword structure main effect.	
Nonword structure	CVC	CVCC
CVCC	.000110	-
CCVC	.000119	.735062

Table 5. Probabilities for post-hoc Student Newman-Keuls tests for Group by pre/post -test interaction.

	Probabilities for post-hoc tests for group X pre/post-test.				
Condition	SRD/pre	SRD/post	RAM/pre	RAM/post	CAM/pre
SRD/post	.679785	-	-	-	-
RAM/pre	.000118	.000118	-	-	-
RAM/post	.000171	.000118	.000119	-	-
CAM/pre	.000132	.000171	.000118	.000118	-
CAM/post	.000142	.000132	.000171	.000118	.012962

Table 6. Probabilities for Student Newman-Keuls tests for group by word unit interaction.

	Probabilities for post-hoc tests for group X word unit interaction (where 1 = SRD group, 2 = RAM group, 3 = CAM group; a = 'onset', b = 'onset and vowel', c = 'rime', d = 'final consonant/s')										
	1a	**1b**	**1c**	**1d**	**2a**	**2b**	**2c**	**2d**	**3a**	**3b**	**3c**
1a	-	-	-	-	-	-	-	-	-	-	-
1b	.0457	-	-	-	-	-	-	-	-	-	-
1c	.0497	.7281	-	-	-	-	-	-	-	-	-
1d	.0006	.1353	.1178	-	-	-	-	-	-	-	-
2a	.0000	.0000	.0000	.0000	-	-	-	-	-	-	-
2b	.0000	.0000	.0000	.0000	.1644	-	-	-	-	-	-
2c	.0000	.0000	.0000	.0000	.7281	.1911	-	-	-	-	-
2d	.0000	.0000	.0000	.0000	.7663	.1578	.7281	-	-	-	-
3a	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	-	-	-
3b	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.6324	-	-
3c	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.2418	.3391	-
3d	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.0000	.7610	.5430	.2613

Table 7. Probabilities for Student Newman-Keuls tests for the nonword structure by pre-test/post-test interaction.

	Probabilities for post-hoc tests for nonword structure by pre-test/post-test				
Condition	CVC/pre	CVC/post	CVCC/pre	CVCC/post	CCVC/pre
CVC/post	.148338	-	-	-	-
CVCC/pre	.000120	.000123	-	-	-
CVCC/post	.000107	.000145	.000135	-	-
CCVC/pre	.000145	.000120	.578490	.000197	-
CCVC/post	.000114	.000107	.000147	.442109	.000118

Table 8. Probabilities for Student Newman-Keuls tests for nonword structure by word unit interaction

	Probabilities for post-hoc tests for nonword structure X word unit interaction (where 1 = CVC, 2 = CVCC, 3 = CCVC; a = 'onset', b = 'onset and vowel', c = 'rime', d = 'final consonant/s')										
	1a	1b	1c	1d	2a	2b	2c	2d	3a	3b	3c
1a	-	-	-	-	-	-	-	-	-	-	-
1b	.0274	-	-	-	-	-	-	-	-	-	-
1c	.0081	.5955	-	-	-	-	-	-	-	-	-
1d	.0057	.3776	.9297	-	-	-	-	-	-	-	-
2a	.0000	.0000	.0000	.0000	-	-	-	-	-	-	-
2b	.0000	.0000	.0000	.0000	.3542	-	-	-	-	-	-
2c	.0000	.0895	.1714	.3124	.0009	.0000	-	-	-	-	-
2d	.0000	.0001	.0045	.0048	.2109	.0337	.1474	-	-	-	-
3a	.0000	.0003	.0060	.0071	.1944	.0247	.1395	.8254	-	-	-
3b	.0000	.0027	.0221	.0317	.0608	.0039	.2008	.6792	.5368	-	-
3c	.0000	.0000	.0003	.0002	.4851	.1618	.0296	.4271	.5676	.3604	-
3d	.0000	.0000	.0000	.0000	.7241	.4068	.0029	.2507	.2691	.1083	.4271

Table 9. Probabilities for Student Newman-Keuls tests for pre-test/post-test by word unit interaction

	Probabilities for post-hoc tests: pre-/post-test X word unit interaction (where 1 = pre, 2 = post,; a = 'onset', b = 'onset and vowel', c = 'rime', d = 'final consonant/s')							
	1a	1b	1c	1d	2a	2b	2c	2d
1a	-	-	-	-	-	-	-	-
1b	.04775	-	-	-	-	-	-	-
1c	.74128	.06215	-	-	-	-	-	-
1d	.68722	.07825	.62042	-	-	-	-	-
2a	.00361	.00003	.00172	.00034	-	-	-	-
2b	.01174	.00002	.00773	.00214	.58213	-	-	-
2c	.00322	.00003	.00132	.00023	.86889	.75439	-	-
2d	.58212	.01475	.65267	.51464	.01175	.02083	.01321	-

APPENDIX E

One-way ANOVA, mean percent of responses, and Student Newman-Keuls tests for real word errors for all groups.

Appendix E *One-way ANOVA for real word errors*

Table 1

One-way Analysis of variance for Group (SRD, RAM, CAM) by percent of real word error responses.

Main effect: Group					
Univar. Test	Sum of Squares	df	Mean Square	F	p-level
Effect	1279.501	2	639.7507	3.368347	0.043980*
Error	7977.066	42	189.9301		

Table 2

Mean proportion of real word errors and standard deviations for each group.

	Descriptive statistics	
Group	M	SD
SRD	44.896	8.243
RAM	41.617	11.298
CAM	32.307	19.344

Table 3. Probabilities for Student Newman-Keuls post-hoc tests for group on percent of real word error responses.

	Probabilities for post-hoc tests for group on percent of real word errors	
Group	SRD	RAM
RAM	.518393	-
CAM	.042453	.071463

APPENDIX F

Two-way ANOVA, means and standard deviations, and Student Newman-Keuls post-hoc tests for number of responses in error pattern categories for SRD and RAM groups

Appendix F *Two - way ANOVA and means and standard deviations for SRD and RAM groups for error pattern categories.*

Table 1

Two-way Analysis of variance for group (SRD and RAM) by error pattern-response. Where 1 = group, 2 = error pattern category.

general manov	Summary of all effects											
Effect	df Effect		MS Effect		df Error		MS Error		F		p - level	
1	1	*	6873.65	*	28	*	365.54	*	18.80	*	.0001	*
2	9	*	3050.73	*	252	*	114.55	*	26.63	*	.0000	*
12	9	*	223.794	*	252	*	114.55	*	1.95	*	.0452	*

Table 2

Mean number of responses in each error response category for children with an SRD and reading-age match controls (RAM).

	Group			
	SRD		RAM	
Error Response Category	M	SD	M	SD
Under 50% similarity	8.466	12.414	1.466	1.846
Onset only included	29.666	28.672	7.066	12.572
Onset and vowel	21.133	11.776	8.600	7.336
Rime only included	16.200	8.108	11.266	6.839
Final letter included	4.733	2.914	1.533	1.597
Beginning and final	14.933	9.896	4.066	5.836
Vowel change	45.666	17.265	33.933	20.502
Consonant cluster reduction	14.266	5.897	7.133	9.898
Letter/s instertion	18.866	9.716	9.733	11.677
50% or greater Similarity	17.866	8.626	11.266	7.136

Table 3. Probabilities for Student Newman-Keuls post-hoc tests for group by error pattern category interaction.

Probabilities for post-hoc tests for group X error category interaction (where s= srd, r= ram; 1= under 50 % similarity, 2= onset, 3= onset-vowel, 4= rime, 5= final, 6= beginning-final, 7= vowel change, 8= consonant reduction, 9= letter insertion, 10= 50% or greater similarity.

	s [1]	s [2]	s [3]	s [4]	s [5]	s [6]	s [7]	s [8]	s [9]	s [10]
srd [1]										
srd [2]	.0000									
srd [3]	.0466	.0290								
srd [4]	.4963	.0051	.5870							
srd [5]	.7748	.0000	.0022	.1123						
srd [6]	.6464	.0022	.5061	.7458	.2127					
srd [7]	.0000	.0001	.0000	.0000	.0000	.0000				
srd [8]	.6745	.0015	.4938	.8738	.2625	.8645	.0000			
srd [9]	.1897	.0157	.5619	.7738	.0182	.7456	.0000	.7646		
srd [10]	.2808	.0135	.6807	.6697	.0373	.7332	.0000	.7935	.7980	
ram [1]	.5540	.0000	.0000	.0119	.8374	.0326	.0000	.0489	.0009	.0025
ram [2]	.9317	.0000	.0193	.3648	.5504	.5342	.0000	.5909	.1028	.1722
ram [3]	.9727	.0000	.0438	.4505	.8602	.5848	.0000	.5951	.1752	.2556
ram [4]	.8906	.0001	.1849	.7144	.6350	.7842	.0000	.7229	.4505	.5392
ram [5]	.4826	.0000	.0000	.0111	.6913	.0299	.0000	.0442	.0008	.0023
ram [6]	.7929	.0000	.0012	.0811	.8645	.1654	.0000	.2127	.0112	.0245
ram [7]	.0000	.2749	.0030	.0000	.0000	.0000	.0026	.0000	.0006	.0003
ram [8]	.7329	.0000	.0177	.3298	.8124	.4846	.0000	.5308	.0935	.1553
ram [9]	.9437	.0000	.0846	.5620	.7964	.6721	.0000	.6521	.2733	.3639
ram [10]	.9528	.0000	.1503	.5870	.7057	.6160	.0000	.4427	.3747	.4408

***Table 3.** (cont.)*

	r [1]	r [2]	r [3]	r [4]	r [5]	r [6]	r [7]	r [8]	r [9]	r [10]
ram [2]	.6063	-	-	-	-	-	-	-	-	-
ram [3]	.6027	.9795	-	-	-	-	-	-	-	-
ram [4]	.2641	.8915	.7738	-	-	-	-	-	-	-
ram [5]	.9864	.4893	,5424	.2363	-	-	-	-	-	-
ram [6]	.7836	.7229	.8558	.5909	.5168	-	-	-	-	-
ram [7]	.0000	.0000	.0000	.0000	.0000	.0000	-	-	-	-
ram [8]	.6962	.9864	.9253	.8281	.6063	.8614	.0000	-	-	-
ram [9]	.4627	.9603	.7718	.6948	.4159	.7743	.0000	.9101	-	-
ram [10]	.2998	.9356	.9038	.9917	.2733	.6537	.0000	.8980	.9186	-